THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 58 Thursday, January 27, 1938 No. 1119

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Vanadium from Cupola Slags

Elsewhere in this issue we print a rather contentious article on the subject of the recovery of vanadium from cupola slags. To our mind, it is in advance of its time. The author assumes that, by impregnating the coke with common salt solution, a slag is produced which is, or may be, in a suitable condition for the extraction of vanadium, titanium and perhaps other rare elements. For many decades, founders have recognised the beneficial inherent properties of certain pig-irons, and metallurgists have postulated various theories to account for these phenomena. Amongst these theories is to be found one which ascribes the improvement as being due to the influence of such elements as vanadium and titanium. There is available some research work, especially of French origin, which has gone a long way to prove that vanadium and titanium, when existing together in a naturally alloyed pig-iron, are distinctly ameliorative in their action. There is usually a metallic loss when melting vanadiferous and titaniferous metallic charges, and efforts directed towards the conservation of these and similar elements should be encouraged. In the article under consideration, however, the transfer to the slag of the vanadium seems to be encouraged. Whilst this may be laudable, the first duty of the foundryman is to obtain from his cupola or other furnace the best metal procurable. We have worked other metallurgical processes where the slag has assumed an importance of almost equal value to that of the metal, but we always had quality of metal uppermost in our minds as being of primary importance and the slag a secondary matter. Moreover, if vanadium and titanium are, as seems probable, beneficial to cast iron, then any attempt to transfer them to slag may result in a deteriorated metal. On the other hand, the passage of chlorine gas through liquid metals has been shown in certain cases to be beneficial by causing *inter alia* a refinement of the grain size. As the liberation may be effected before the iron is melted, this action may be of no value, whilst, if carried out in the ladle, special provision would have to be made to evacuate the fumes, and to protect any nearby ironwork from attack. An interesting experiment would be first to impregnate the coke with salt and then to encase it in lime so as to prevent combustion until it reached the fusion zone of the cupola. In suggesting this, we take no responsibility for the action on the refractories, or other untoward experience! The whole of our thoughts on this subject are prompted by the idea of soaking coke in salt solution, as is suggested by the article.

The Metallurgical Nursery

Some figures disclosed in a recent lecture by Dr. R. S. Hutton are of interest to all engaged in the foundry trade. There are something like ten universities and university colleges in this country offering specialised instruction in metallurgy, and it is usual for students to-day to take an honours degree. Yet in 1934-35 the number of honours degrees awarded was only 20, and in the following year only 14. This does not reflect on the number of students taught in these departments, for they deal with students of engineering, mining, dentistry, and so on, who take metallurgy as a subsidiary subject. But it does reflect on the number of men who go to a university to study metallurgy as a principal subject, for there are twenty-five times as many students taking chemistry. Yet the chemical industry fed by these students has an output of about 80 millions sterling and employs about 88,000 people, while the metal industries have an output valued at over 300 millions sterling and employ nearly half-a-million people. If in this country the number of advanced students in metallurgy is about 4 per cent. of those in chemistry, the corresponding figure in the United States is about 3 per cent. and in Germany 6 per cent. The actual number of graduates in metallurgy is very small when it is remembered that they have to feed the extractive as well as the manufacturing sides of the industry both at home and in the Empire. Some, indeed, go to engineering and chemical works not strictly in the metallurgical industries.

Looked at from another point of view, and assuming that in modern industrial countries responsible and key positions in industry must be filled by trained men, we find that in the United Kingdom in 1934 there was one university student to 885 people in the country. In Germany the corresponding figure is one in 600, in spite of a reduction in numbers of students between 1932 and 1934 to about one-half. France, Italy, Holland, Sweden and Switzerland all have better figures than we have, and in U.S.A. the figures are still more striking. We are bound to assume that our people are as intelligent, and that our industries demand as much intelligence. Actually they demand more if we are to maintain our high standard of living in the face of competition. We propose to give our conclusions on this subject next week.

Institute of British Foundrymen

ELECTION OF NEW MEMBERS

At a Council meeting of the Institute of British Foundrymen in Bristol on January 15, the following were elected to the various grades of membership:—

As Subscribing Firms.

Coneygre Foundry, Limited, ironfounders, Tipton, Staffs (representative, W. L. Graham); Hartley's Malleable Fittings Company, Limited, malleable ironfounders, Halifax (representative, C. D. Wilson); Rolls-Royce, Limited, Derby (representative, J. Vickers).

As Members.

C. T. Eddlestone, foundry manager, Eddlestone & Company, Limited, Padiham; E. Fisher, works manager, Rycroft & Company, Limited, Bradford; C. Gierdziejewski, general manager, Metallurgical Works, P.Z. Triz, Warsaw; F. C. S. Hanauer, assistant manager, Laidlaw, Drew & Company, Limited, Edinburgh; W. Hartley, assistant foundry manager, Hartley's Malleable Fittings Company, Limited, Halifax; J. G. Houlston, timber merchant, H. W. Bloomer, Ardwick, Manchester; W. J. Kitching, manager, Leigh & Sillavan, Limited, London; D. Lumb, representative, Foundry Services, Limited, Birmingham; W. R. Marsland, technical and foundry adviser, Newman, Hender & Company, Limited, Woodchester; C. B. Northey, tool designer, British Rola Company, London; J. F. Rastall, brass founder, J. Rastall & Son, Manchester; G. T. Reid, assistant foundry manager, North Western Railway, Lahore; J. A. Richards, assistant general manager, Crane Foundry Company, Limited, Wolverhampton; C. M. Salmond, assistant works manager, Shaw (Glasgow), Limited, Glasgow; F. Swift, steelfoundry manager, Darlington Forge, Limited, Darlington; F. Williams, director, Markham & Company, Limited, Chesterfield.

As Associate Members.

T. Alexander, foreman moulder, C.M.E. Dept. Rly. Works, Nigeria; J. S. Bagnall, B.Sc., metallurgist, National Gas & Oil Engine Company, Limited, Ashton-under-Lyne; F. N. Bennett, moulder, Russell Edwards & Company, Limited, Bamber Bridge; A. Boyes, assistant foreman, Metropolitan-Vickers Electrical Company, Limited, Manchester; C. D. S. Bridgett, B.Sc., metallurgist, Royal Ordnance Factory, Birtley; H. T. G. Brown, metallurgical chemist, E. R. & F. Turner, Limited, Ipswich; G. Burgess, assistant metallurgical chemist, Hepworth & Grandage, Limited, Bradford; J. W. Etchells, patternmaker, Union Pattern Works, New Mills; W. C. Fearn, steel moulder, Vickers-Armstrongs, Limited, Barrow-in-Furness; R. Fitzjohn, assistant foreman moulder, Hepworth & Grandage, Limited, Bradford; H. W. Fitzpatrick, assistant manager, W. & J. Lawlers, West Bromwich; G. C. Forrest, traveller, Ashmore, Benson, Pease & Company, Limited; W. Freeland, foundry foreman, English Steel Corporation, Sheffield; H. Green, foreman patternmaker, Roberts Castings, Limited, Huddersfield; H. C. Heaford, foundry foreman, Midland Motor Cylinder Company, Limited, Smethwick; H. J. Higgins, moulder, H. Bisseker, Limited, Birmingham; W. H. Hornby, iron moulder, Little Lever Iron Works, Bolton; F. H. Hoult, estimator, Aero Engines, Limited, Bristol; F. Kay, foreman patternmaker, Hunt & Moscrop, Limited, Middleton; E. W. Kennard, British Bath Company, Limited, Greenford; A. King, foreman moulder, English Steel Corporation, Sheffield; G. P. Kirk, company secretary, N.E. Iron Refining Company, Limited, Stockton-on-Tees; H. W. Knight, foundry assistant, Ashmore, Benson, Pease & Company, Limited, Stockton-on-Tees; J. Livingstone, foreman moulder, A. F. Craig & Company, Limited, Paisley; W. W. J. Llewellin, assistant foundry foreman, Fine Castings, Limited, Bristol; E. Mansfield, foundry foreman, English Steel Corporation, Sheffield; D. Menzies, metallurgist, Beyer, Peacock & Company, Limited, Manchester; C. F. J. Milson, foreman metal patternmaker, Brecknell, Munroe & Rogers (1928), Limited, Bristol; T. Newsham, assistant foundry foreman, Ajax Casting Company, Lancaster; J. A. Ormrod, foreman moulder, F. R. Cass, Limited, Bury; G. Pearson, assistant metallurgical chemist, Hepworth & Grandage, Limited, Bradford; W. D. Powell, foundry foreman, W. Dove & Sons, Limited, York; J. H. Price, foundry foreman, H. J. Maddock & Company, Limited, Oakengates; A. F. Puddicombe, engineer, Wellington; J. Rutherford, assistant foundry manager, W. Beardmore & Company, Limited, Glasgow; A. Shrimpton, patternmaker, Austin Motor Company, Birmingham; G. A. Smith, foundry foreman, B.T.H., Rugby; W. J. Stubbings, foundry foreman, J. Robinson & Sons, London; D. Thomson, foundry manager's assistant, Steel Company of Scotland, Limited, Glasgow; G. C. Turner, assistant works manager, D. Crabtree & Son, Limited, Bradford.

As Associates.

T. A. Bird, apprentice draughtsman, Sir W. G. Armstrong, Whitworth & Company, Limited; R. Corking, iron moulder, Ashmore, Benson, Pease & Company, Limited; C. D. Fletcher, apprentice foundry metallurgist, Fletcher, Houston & Company, Limited, Tipton; G. Jackson, moulder, Ferranti, Limited, Hollinwood; A. Lonsdale, iron moulder, Ashmore, Benson, Pease & Company, Limited; T. McCarthy, pattern moulder, Howard & Bullough, Limited, Accrington; J. McKinnon, cupola overseer, Bennett's Ironfoundry Company, Limited, Stockport; E. Mayes, moulder, Howard & Bullough, Limited, Stockport; T. W. Merrington, moulder, W. Shaw & Company, Limited, Middlesbrough; C. J. Ramsbottom, traveller, Steel Sales Company of South Africa, Limited, Johannesburg; F. Stanney, pattern moulder, Ferranti, Limited, Hollinwood; H. Stephens, iron moulder, Ashmore, Benson, Pease & Company, Limited; J. W. Travers, castings salesman, Steel Sales Company of South Africa, Johannesburg; G. Wells, foreman moulder, Eddlestone & Company, Limited, Padiham.

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W. D. Freight, apprentice patternmaker, Parsons Marine Steam Turbine Company, Limited, Wallsend; F. Reep, Oxford Foundry, Kidderminster; J. N. Sherar, foundry student, Qualcast, Limited, Derby; G. F. Taylor, steel moulder, Head, Wrightson & Company, Limited, Stockton-on-Tees; R. C. J. Wilson, apprentice moulder, Evans Titan Foundry Company, Cardiff.

Catalogue Received

Industrial Stoves. In a section of a catalogue devoted to industrial stoves, issued by Alfred Allen & Son, Limited, of Lower Gornal, near Dudley, Staffs, and received through their London agents, Reynolds, Lechem, of 18, Queen Victoria Street, E.C.4, there is much to interest foundry executives, for in it are given illustrations and details of plant for lacquering, japanning and stove enamelling, as well as core and mould stoves. Entering into the last category are single, double, and trebly cased ovens. These are arranged for heating by gas, steam, oil, electricity, hot air or surface combustion using town's gas as fuel. An improvement to this catalogue could be effected by transferring the matter on the back of the front cover to the end of the letterpress, using this page for indicating some of the services given by the firm. For example, much more might have been made of the fact that the firm designs stoves and handling equipment to users' specifications.

Random Shots

It has come at last! A correspondent has put forward to the Editor the idea that all technical Papers given at international gatherings should be in two languages only—the mother tongue of the author and in Esperanto. Surely the cup of the seeker after knowledge is already full enough? Besides, would it not mean attending yet another evening class? And has not it already been decreed that the foundry youth shall join the Boy Scouts instead of the night schools?

Now supposing a few diligent men set to learn this new lingo and tried it out at the next international dinner of the foundrymen. Would not Mr. Vanzetti choke himself with laughter at his neighbour's attempt to talk Italian. Mr. Brizon would pity the "pauvre bête" who had picked up his French on the Spanish frontier and was passing it off as Parisian, whilst the delegates from Germany, Poland and Czecho-Slovakia would look on in bewilderment, bemoaning the fact that they never could understand the Englishman's particular type of humour.

* * *

A new phase of mechanisation is manifest in the substitution of gramophone records for church bells in certain rural parishes, and bell founders will have to look out for their bread and butter. It would come hard on that industry to have to orient its ideas of manufacture from bells to gramophones, for bell founding is so patently a family trade, with a craftsmanship handed down from father to son throughout the generations.

* * *

By the way, which sounds worse—the dead, dull thud of a cracked church bell, or the monotonous hiccough of a gramophone record, as the needle strikes the crack at each revolution? Either alternative sounds so uninviting that it might be advisable to take a sleeping draught of a Saturday night to avoid the possibility of being entertained to either next morning.

"MARKSMAN."

A Bronze Plaque

The bronze plaque illustrated below is the latest example of Mr. John Longden's skill in the field of sculpture and art founding. The plaque

BRONZE PLAQUE BY MR. JOHN LONGDEN.

carries in high relief a life-size bust of Mr. David K. Tullis, chairman of D. & J. Tullis, Limited, laundry engineers, of Clydebank.

Cupola Practice*

By S. E. DAWSON, F.I.C., A.M.C.Tech. (Stanton Ironworks Company, Limited)

For general utility purposes, the cupola is still the principal melting unit in the foundry, due largely to the relatively low capital outlay involved, the ease and adaptability of its working and maintenance, and its economic melting cost. Unlike the open-hearth type of furnaces, the cupola sets some limit on the choice of raw materials, excluding as it does, except under special circumstances, the use of borings and swarf, as well as large metal pieces, and limiting the use of ferro-alloys of high melting point.

These materials, however, are generally associated with the manufacture of special-duty cast irons, and their melting might be considered as outside the scope of the ordinary foundry cupola, although much can be done in the latter towards the production of improved cast irons by modifications, both in the conditions of melting and the raw materials used within the limits referred to.

Developments in design of the cupola have generally been directed towards improved combustion of the fuel by better distribution of the air supply, and although it has retained its original form of construction, such modifications as pre-heating the air supply, as in the hot-blast type, supplying secondary air to promote more complete combustion, as in the Poumay system, or controlling the primary air by adjustable valves to ensure more regular combustion, as in the balanced-blast cupola, are the results of efforts in this direction.

Although some liberty in design may be taken in certain cases, the main points to observe in selecting a cupola are briefly set out below.

The internal diameter largely determines the melting rate of the cupola, which for normal working should be 10 to 12 lbs. of metal per hr. for each sq. in. of bore at the melting zone.

Height of Tuyeres

The height of the tuyeres above the cupola bottom controls the capacity of the well or bath of metal, the required size of which depends to a large extent on the frequency of tapping to meet the particular size and quantity of castings to be produced. Where a receiver or forehearth is employed, the well can be reduced to a minimum, so that the hot melting zone is as near as possible to the bath of metal and coke to maintain maximum heat in both. In this case, a height of about 12 in. is usually sufficient, as compared with 24 in. or even more where no receiver is in use.

Blast Main and Wind-Belt

The blast main should be large enough to carry the required volume of air with as little friction as possible. This is generally to be obtained with a pipe diameter of about one-third of the internal diameter of the cupola. The wind-belt should be large enough to give a steady pressure into the cupola, and the total tuyere area such as to give suitable penetration of the air under this pressure to the centre of the charge, to ensure as far as possible an even spread over the charge.

Tuyeres

The size and disposition of tuyeres have been a subject of much discussion, and some latitude is often taken to meet certain local conditions of charging and raw materials. Generally, however, it will be found that a total tuyere area of one-quarter to one-seventh of the cupola area at that level gives the most satisfactory result, such a ratio giving a "soft" blast whilst still penetrating to the centre of the charge.

The use of two rows of tuyeres at different levels is designed primarily to effect the conversion of carbon monoxide produced at the lower row to carbon dioxide at a higher level, although it is more probable that the advantage of this system is due rather to the more effective distribution of the air. An upper row of tuyeres of equal area to the lower provides more air than that required for such secondary combustion, and if the rows are widely spaced to be effective in this manner, an undesirable second combustion zone may be set up. In this connection, the balanced-blast cupola, described later, more suitably meets the conditions required.

Depth of Charge

The charging door should be in such a position up the stack that the heat from the ascending gases or products of combustion is extracted by the descending charge to the fullest extent, without being too high to create unnecessary resistance against the blast and the passage of exhaust gases. This is generally obtained by a cupola capacity to hold charges for about one hour's melting. The height of the stack above the door is designed to give sufficient draught to kindle the bed and to permit of easy removal of the products of combustion, a height about equal to the depth of the charge being sufficient for this purpose.

Linings

The lining of the cupola is generally in the form of good-quality firebricks or blocks made to suit the particular diameter of furnace concerned. From the melting zone downwards special high-refractory alumina blocks are often used, and above the charging door a cheaper grade of firebricks may be employed. The thickness should be sufficient to withstand the ordinary melting operation without burning through, and yet not too thick as to absorb too much heat from the gases to the detriment of the temperature of the metal.

Fettling between heats to re-establish the lining to its original diameter is generally carried out by the use of a good-quality ganister, after chipping away any roughness due to slag, cinder, etc. Where the lining has been seriously eroded, as on long blows, all firebricks or blocks of suitable size are built in with the ganister, and serve also to reduce the quantity of the latter required. The amount of such fettling required depends on the conditions of working the cupola, and on the quality of ganister, but may be taken as varying from 25 lbs. per ton of metal for long blows up to 60 lbs. per ton or higher for short blows.

Weight of Charges

The size of charges to be used is largely determined by the diameter of the cupola, which, as already mentioned, has been selected to give a required capacity or rate of melting. The coke charge, calculated or measured at about 6 to 8 in. depth in the stack, determines the weight which should be used, and this in turn gives the iron charge of, say, 8 to 12 times the coke ratio, and also the amount of air required for combustion.

Theoretically, 1 lb. of coke (90 per cent. carbon) requires 10½ lbs. of air, or about 140 cub. ft., for complete combustion, but in cupola practice it is found that an excess of 10 to 20 per cent. is necessary to achieve this object. The heat produced from 1 lb. of coke would melt and superheat considerably more than ten times its weight of iron, in addition to raising the temperature of the slag, furnace walls, etc., and iron to coke ratios of 18 : 1 have been obtained with excessive air at increased pressure. Such conditions, however, bring about serious oxidation of iron, with excessive losses, and give metal of increased shrinkage.

Air to Coke Ratio

To illustrate the importance of a correct balance of air to coke, the following test is of interest. Observations were taken daily on several thousands of castings made from the same pattern. With excessive air, the iron was doubtless oxidised and rejections were high, and not until the proportion was brought to about 165 cub. ft. per lb. of coke, could satisfactory castings be produced.

The main items in the data taken are set out in Table I.

TABLE I.—*Influence of Air to Coke Ratio on the Rejections.*

Test No. :	1	2	3	4	5	6
Air (cub. ft.) per lb. coke ..	233	197	183	179	164	165
Rejections (per cent.) ..	11	8.7	8.0	6.8	1.3	1.0
Ratio $\frac{\text{iron}}{\text{coke}}$	13.3	12.5	11.5	10.6	10.6	10.5
Time blowing (hours) ..	7.3	7.4	7.4	7.4	7.5	7.0
Rate of melting (tons per hour)	7.67	8.5	8.35	8.0	8.0	7.6
Air per ton of metal (cub. ft.)	39,000	35,000	36,000	38,500	34,500	35,200
Diameter cupola / Tuyere area	2.9	3.24	3.24	3.24	3.24	3.24
Temperature at spout, deg. C.	1,330	1,340	1,370	1,380	1,390	1,400
Analysis—						
Total carbon	3.27	3.44	3.29	3.23	3.09	3.45
Silicon	2.69	2.30	2.15	2.29	2.38	2.42
Phosphorus	1.00	0.97	0.90	1.01	0.93	1.05

Where long blows are necessary the lining should be more substantial than for short blows, and up to 15 in. is not uncommon on cupolas up to 60 in. diameter.

In some cases the lining is put in as a double layer so that the inner bricks can be replaced when necessary without disturbing the outer layer. For a similar reason, rings are often bolted on to the casing to support the lining in sections so that certain portions in need of repair can be removed independently of brickwork higher up the stack.

Monolithic linings rammed round a former and dried and burnt *in situ* have been used in some cases. The preparation of such a material is an important factor in its successful application, and careful initial heating up is necessary.

More efficient production and utilisation of the heat available from the coke are obtained in the balanced-blast cupola, the design of which is familiar to most foundrymen. In this type of furnace the object has been to provide better distribution of air in the lower portions of the coke bed, through which the molten metal passes and where superheating takes place. Both objects are accomplished by supplying only sufficient air or a relatively "soft" blast to the coke bed to provide carbon monoxide (CO), whilst the remainder of the air is projected in at higher levels to burn the carbon monoxide to carbon dioxide (CO_2).

The lower air is admitted through large valved tuyeres, whilst a graded size of small auxiliary tuyeres, of pre-determined area and successive

* Paper read before the Bristol Section of the Institute of British Foundrymen.

rows, usually three, gives progressive combustion of the CO to CO_2 and a gradual increase in temperature to the top of the coke bed.

A high pressure maintained in the wind-belt secures better penetration of air from the auxiliary tuyeres across the section, giving a more uniform gas atmosphere and temperature at the melting zone. Such uniformity in gas composition minimises the oxidation of the metal, which in the ordinary cupola mainly takes place in the outer annulus, where the gases are strongly oxidising and the heat is greatest.

The greater efficiency of combustion in the balanced-blast cupola is shown in the following analysis (by volume) of the top gases taken over several hours' run by Mr. J. E. Fletcher, the designer of the furnace, in two cupolas similar in every respect except that one was fitted with the special wind-belt tuyeres.

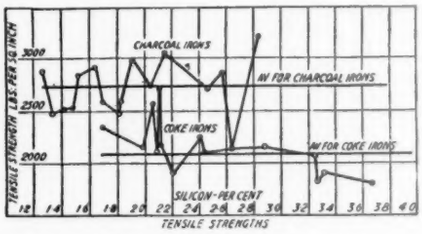


FIG. 1.—TENSILE STRENGTHS OF CHARCOAL-MELTED AND COKE-MELTED IRONS.

	Normal cupola. Per cent.	Balanced-blast cupola. Per cent.	Complete combustion. Per cent.
Carbon dioxide ..	12.8	18.5	20.7
Carbon monoxide ..	8.9	1.4	0.0
Oxygen	0.4	0.6	0.0
Nitrogen	77.9	79.5	79.3

The efficiency of combustion and better distribution of the heat was reflected in the coke consumption, which was between 30 and 40 per cent. less than for the original design of cupola.

Continuous tapping through a syphon block is a feature of many cupolas to-day, and has several advantages to commend it, including hotter metal, less attention to tap hole, and less wear on the cupola lining below the tuyeres.

The methods of charging the cupola range from hand charging in small single units to automatic charging in large multiple installations. Two methods illustrating the latter were shown on the screen—the loading into skips, weighing, conveying and charging, indicating the transfer of large tonnages of raw materials into cupolas working continuously for practically 24 hours.

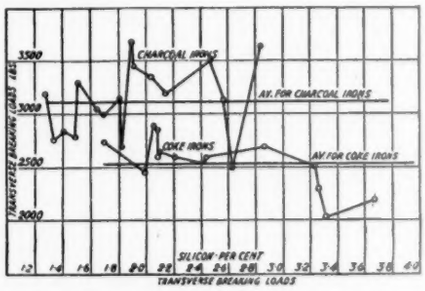


FIG. 2.—TRANSVERSE STRENGTHS OF CHARCOAL-MELTED AND COKE-MELTED IRONS.

Influence of Cupola Practice on the Metal

Much consideration is now being given to the structure and physical properties of the irons entering into the composition of the cupola charge, and evidence is now available to indicate that certain of the properties exhibited by the raw materials employed persist through the subsequent remelting in the cupola to influence the resulting metal. (This is partly explainable by the theories of Norbury and Morgan relating to slag inclusions, a process based on which is briefly referred to later.) This is of special interest to the user of special refined irons for special high-grade purposes.

Hurst showed that by the selection of raw materials of selected physical properties in addition to chemical composition, predetermined chemical properties in the final metal can be secured by suitable blending. In perhaps a lesser degree, some scientific evidence is also seen for the use of scrap in most cupola charges which, whilst introducing a serious unknown factor into the calculation, is of somewhat different structure, and of finer graphite form, than pig-iron of similar composition. A study of the many influences which have been shown as affecting the structure and behaviour of cast iron affords some indication of the new light which is being brought to bear on the subject, and it is reasonable to suppose that the control of cast iron will include many factors in addition to that of composition.

In this connection, it is interesting to refer to the investigations carried out by A. L. Boegehold, which were largely concerned with the examination of cast iron melted under constant conditions in a cupola from pig-irons produced in seven different blast furnaces. The cupola charges for the remelts included in all cases the selected pig-iron and scrap from a previous melt of the same pig-iron, and test specimens were taken from the middle of the melt at a pouring temperature of 1,330 to 1,370 deg. C. He found that blast-furnace conditions produced characteristics in the pig-iron which persisted through subsequent melting in the cupola. This was especially observed with regard to hardness and fluidity, and the dilatometer test curves, which were of the same form for the pig-iron as for the corresponding remelted iron.

In many foundries the air-coke ratio is too low, with the result that carbon pick-up is experienced to the detriment of the structure and mechanical strengths, and the temperature of the metal is far from satisfactory. With a more correct ratio, the amount of total carbon can be better suited to the particular castings, and a close-grained iron obtained. The quality of coke is also of considerable importance, and the comparative results obtained by W. E. Jominy when melting iron in the blast furnace by means of charcoal and coke are interesting.

Electric Furnace Experiments

In all, about one hundred lots of iron were examined, and again the pig-iron was remelted under constant conditions to reduce subsequent variables to a minimum. An electric furnace was employed for this purpose, and the analyses showed that little change in composition had occurred. The iron was remelted at 1,430 deg. C., and, as in the case of the iron from the blast furnace, poured into test-bars 1¼ in. dia. by 15 in. long. The irons he employed were of considerable and useful range, and the mechanical tests taken included those on the original pig-iron as well as on the remelted and twice-remelted cast iron. The tensile and transverse strengths

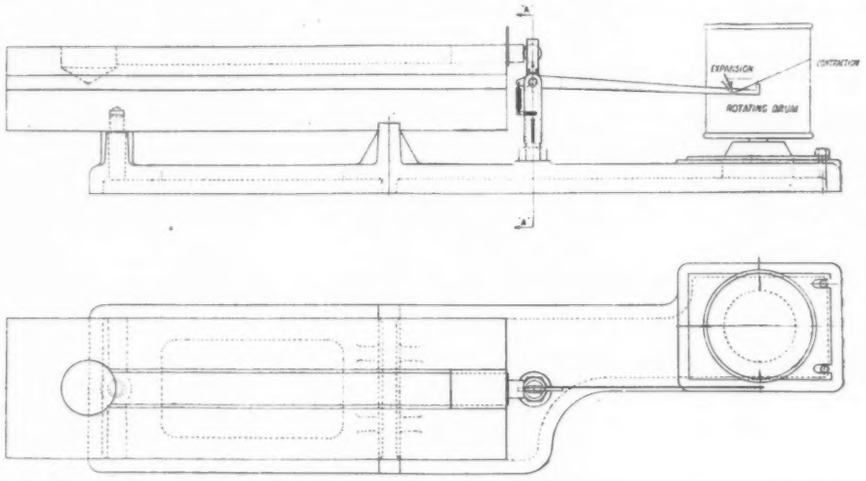


FIG. 3.—DIAGRAM SHOWING APPARATUS USED TO SECURE COOLING CURVES OF CAST-IRON TEST-BARS.

in the case of the first remelt and for equal silicons are given in Figs. 1 and 2, which show the charcoal-melted irons to be 20 per cent. stronger than the coke-melted irons.

On remelting a second time, this difference had persisted. Whilst the analyses were similar in the comparative cases, the micrographs revealed a considerable difference in the structure, especially as regards graphite. In the charcoal-melted iron, the graphite was small and well distributed, but in the coke-melted irons it was coarse.

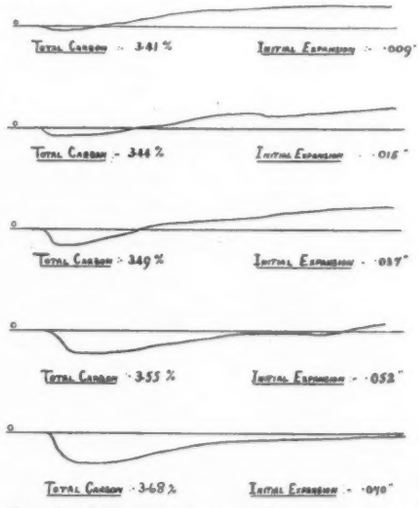

TOTAL CARBON - 3·41 %
INITIAL EXPANSION - ·009"
TOTAL CARBON - 3·44 %
INITIAL EXPANSION - ·018"
TOTAL CARBON - 3·49 %
INITIAL EXPANSION - ·037"
TOTAL CARBON - 3·55 %
INITIAL EXPANSION - ·052"
TOTAL CARBON - 3·68 %
INITIAL EXPANSION - ·070"

FIG. 4.—SPECIMEN COOLING CURVES SHOWING VARIATION OF INITIAL EXPANSION WITH TOTAL CARBON CONTENT.

In a different category, perhaps, is the theory of the influence of silicates of iron present in a colloidal or ultramicroscopic condition, sometimes referred to as silicate slime, shown by O. von. Keil and others to produce large coarse graphite. The assistance rendered by the removal of such silicates by superheating the metal may be a direct contribution to the improvement in structure obtained by such treatment.

(*Concluded on page* 100.)

Production of Flange Pipe Templets or Closures

The manufacture of templet pipes calls for great care and forethought. As the term implies, the piece is to fill up the last portion of a pipe line, and consequently it must be machined and drilled with great accuracy; otherwise it will cause waste of time and money. The writer over a period of years has had many interesting experiences with such pipes, varying from 2 in. to 36 in. bore. Erecting engineers do not all see eye to eye in the matter of securing particulars of such items; some prefer to make wooden templets, and others to measure up on site. Founders also do not agree as to which is the better method. Some foundries object to using wood templets, as these have first to be placed on the marking-out table and measured up, and there is the ever-present risk of mistakes. Again, the patternmaker makes use of the wood templet in the mould to set his flanges by, and frequently this makes a bad mess of the mould and materially delays progress, and in this direction delays are looked upon as serious items, because templet pieces are usually required urgently. On the other hand, some foundries prefer templets to sketches.

The writer has definite views on the issue, and condemns the templet system on the score that the templets are made in the cheapest way and do not in any way show the correct shape of the casting. This in some cases does not matter, but in others the body line may have to miss existing machinery or buildings, and if a dimensioned drawing is submitted, the shape must be shown, and so the manufacturer is relieved of unnecessary responsibility.

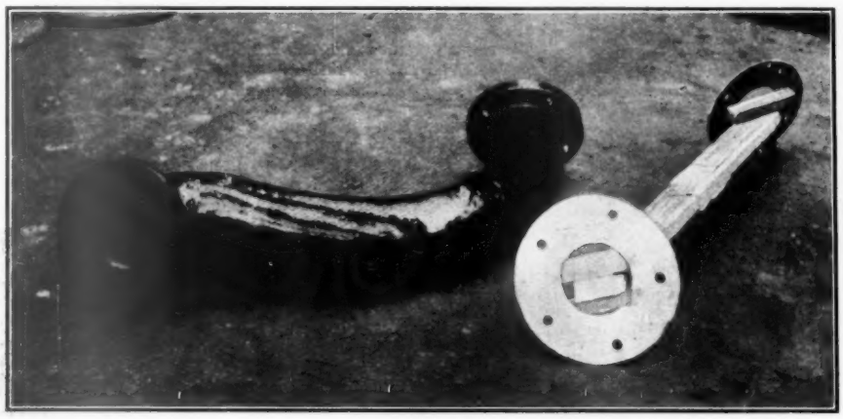
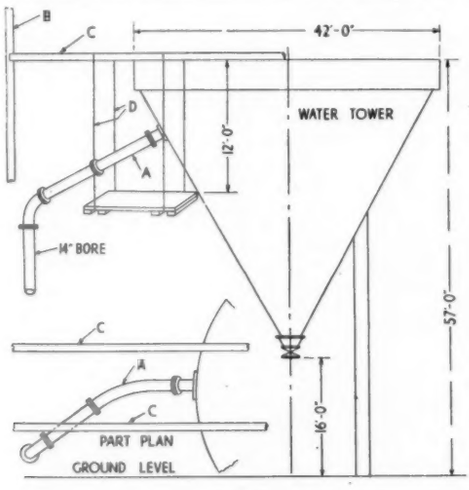


FIG. 1.—WOOD TEMPLET AND FINISHED CASTING, SHOWING HOW THE FORMER GAVE NO INDICATION OF THE ACTUAL SHAPE OF PIPE REQUIRED.

Fig. 1 is an excellent example showing that the casting in no way resembles the templet, only in as much as the set of the flanges is similar. This templet arrived from the site only with a covering note ordering a casting to be put in hand. It happened, in this particular case, that the writer was familiar with the job, and he took up with the erector the question of omissions. This educed the eventual shape of the casting. This is a typical case where, had the casting been made a less expensive shape, the foundry could not have been held responsible, and where, had a dimensioned drawing been supplied, the correct shape would have been indicated.



ELEVATION

FIG. 2.—OUTLINE SKETCH SHOWING DISPOSITION OF TEMPLET PIPE (A) FOR A WATER TOWER, AND THE ARRANGEMENTS MADE TO SECURE NECESSARY MEASUREMENTS.

Measurement on sites demands the attention of an experienced person, and is a job that must be done with care to avoid the risk of accidents. Fig. 2 shows a typical example of a rather tricky job. The templet required here is marked A, and is in connection with the circulating pipes on a conical washing tower. This tower is 57 ft. above ground level. The scaffolding used in the erection of the tower and for erecting the pipework had been taken down, so a fresh one had to be erected. This is shown in the form of a platform slung from beams C over, and carried by ropes D. As the platform, however, would not remain stationary, but rather reminded one of a swing, guy ropes had to be connected. It is necessary that such scaffolding be quite rigid to enable measurements to be correctly taken. It took the writer and an assistant two hours to measure up this templet.

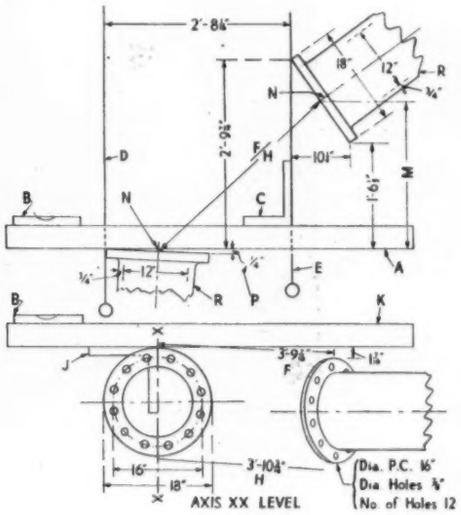


FIG. 3.—MEASUREMENTS TAKEN FOR A 12-IN. BORE OBTUSE CLOSER.

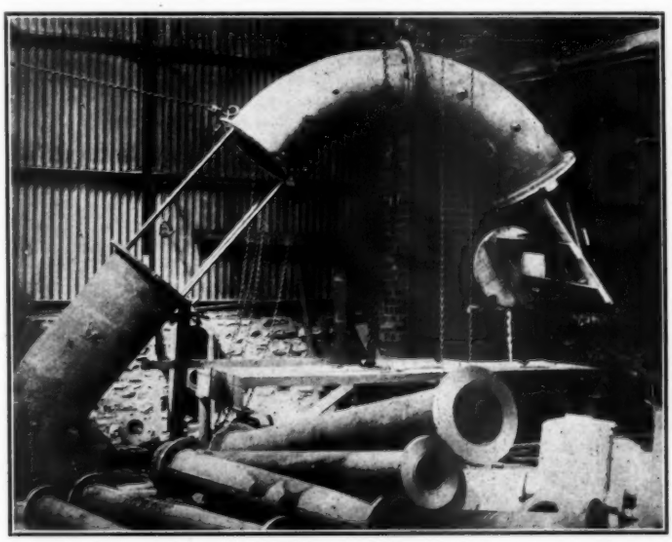


FIG. 4.—PIPES AND WOOD TEMPLET IN POSITION, WITH GAP FOR STRAIGHT PIPE WHICH IS TO BE THE FINAL CLOSING PIECE.

A 30-in. Bore Closure

A further example is a 30 in. bore closure which is a double offset about 7 ft. long. From a different viewpoint it illustrates yet another reason why measurements should be taken in preference to a templet being made. The erector had a templet made, which occupied two joiners

six hours each, while the cost of the wood was approximately 45s. This templet had to be sent by rail from the site to the foundry, with the attendant risk of damage in transit, and had it become distorted in any way, no one would have been the wiser until the casting was being erected. Such a casting would cost between £30 and £40, and it would, therefore, be of serious consequence to someone if it had to be re-made on account of inaccuracy.

Fig. 3 shows the actual measurements which were taken of a 12 in. bore obtuse closer on a job. It will be seen that many measurements had to be taken to ascertain the correct angles and the like. For instance, the flange is shown dipping ¼ in. at P, and the centre-line of the bolts' axis X-X did not run parallel with the other flange, as shown by measurements F and H. Of the other letters shown on sketch, B is a spirit level, C is a square, and D and E are plumb lines. R and R are existing pipes which had to be closed; A and K are straight edges.

The work of taking measurements must be carefully done, and in this direction the following advice may be of use to those perhaps out on their first job.

(1) Always take plenty of measuring tools; do not expect to find them on the job.

(2) Do not let the assistant (as one will be provided on the site) take measurements; the foundry executive is solely responsible.

(3) Do not miss any measurements; this may require another visit and may create trouble.

(4) Do not take angles, as these may be elusive, and measurements are preferable.

(5) When a survey is finished, look over the findings, to ensure that nothing is left undone.

(6) If bolt holes on existing pipes are ¾ in. dia., have those in the templets drilled ⅞ in.; the erector will welcome this.

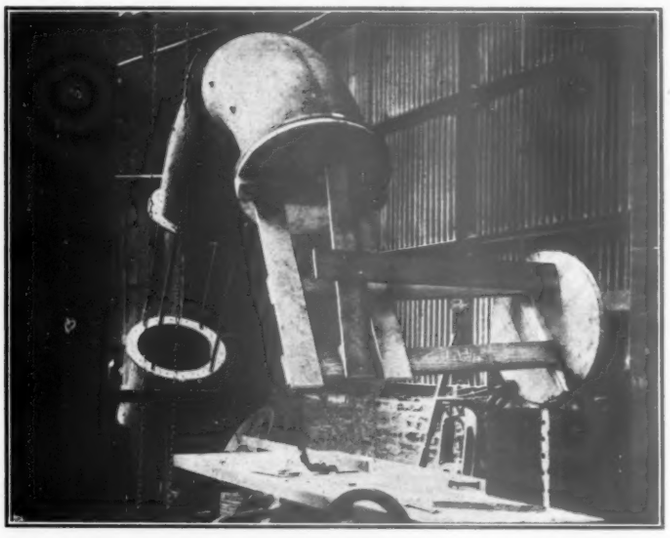


FIG. 5.—ANOTHER VIEW OF THE SET-UP SHOWN IN FIG. 4.

"Further Particulars"

Figs. 4 and 5 show another aspect of templet pipes. On some pipe lay-outs, *i.e.*, the drawings which are issued from the designing office, certain templet pipes are shown with the remark "further particulars later from the job." In many instances the wrong piece has been marked for the templet item. It may be in a very difficult place to take the measurements, and it may be that the piece is a very awkward shape. Thus the final closure should only be decided upon after careful consideration of all points.

It will be noticed in these two illustrations that three pipes and a wood templet are slung up in position, with a space left blank. This space left blank is to be the finishing templet pipe. The wooden item is the shape of the casting that is to be made for first erection, and was shown detailed on the drawing. The flanges on this item, however, were so badly dimensioned that the foundry could not set out the work from the drawing, and to save further loss of time it was decided to set it up in this way and make the wood shape. It is obvious that the final closing piece ought to have been the bend and not the straight pipe.

Cupola Practice

(*Concluded from page* 98.)

More recently the effect of treating cast iron with carbon dioxide in the presence of a small amount of titanium* with progressive refinement of the grain and graphite as such treatment proceeds, indicates a further direction in which a measure of control of structure may be obtained. The effect of conditions of mixing and melting on the metal has already been referred to, and the author has endeavoured to obtain some indication of these from the cooling curve of the metal itself.

Cast irons of known compositions, made from different raw materials, and melted to various temperatures, were poured into a test apparatus shown in Fig. 3. The change in volume of the test-bar was recorded on a chart attached to a drum. Initial expansion of the iron due to separation of graphite was indicated below the zero line, and contraction above the line followed later in the normal course. Intermediate expansion due to phosphide separation or other causes was also clearly shown. A copy of a series of charts to show the effect of carbon is seen in Fig. 4. Similar curves are obtained also by merely holding the metal at a constant temperature, when changes take place to influence the expansion of the metal as a whole.

* B.C.I.R.A. Patent No. 425227/35.

(*Concluded from next column.*)

seats or tables for the dinner. Members who have paid for tickets and, later, find that they are unable to use them, may obtain refunds if their applications for such refunds are in the Secretary's hands not later than first post on Monday, March 7. Tables (to seat six to ten persons) will be reserved for parties making early application for tickets.

Further particulars of the meeting may be had from Mr. G. Shaw Scott, Secretary, 36, Victoria Street, London, S.W.1.

The Institute of Metals

ANNUAL GENERAL MEETING IN LONDON

The thirtieth annual general meeting of the Institute of Metals will be held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on March 8, 9 and 10. The following is a programme of the meeting.

TUESDAY, MARCH 8.

7 p.m.-8 p.m.—General Meeting. The Report of the Council and the Report of the Honorary Treasurer will be presented. The results of the elections of the Council for the year 1938-39 and of new members will be declared.

8.15 p.m.—The new President will be inducted into the chair, and will deliver his address. Light refreshments will be served after delivery of the Presidential Address.

WEDNESDAY, MARCH 9.

10 a.m.-12.30 p.m.—The following Papers will be presented for discussion:—

"The Nickel-Copper-Magnesium Alloys," by W. R. D. JONES and K. J. B. WOLFE.

"Alloys of Magnesium. Part VII. The Mechanical Properties of Some Wrought Aluminium-Magnesium and Silver-Aluminium-Magnesium Alloys," by J. L. HAUGHTON and A. E. L. TATE.

"Sintered Alloys. I.—Copper-Nickel-Tungsten Alloys Sintered with a Liquid Phase Present," by G. H. S. PRICE, C. J. SMITHELLS and S. V. WILLIAMS.

"The Creep of Tin and Tin Alloys. Part II," by D. HANSON and E. J. SANDFORD.

12.45 p.m.—Members who so desire will lunch together at St. Ermin's Restaurant (*table d'hôte* meal, 3s.).

2 p.m.-4.30 p.m.—The following Papers will be presented for discussion:—

"The Physical and Mechanical Properties of Nickel-Brasses," by M. COOK.

"The Influence of Alloying Elements upon the Crystallisation of Copper. Part I.—Small Additions and the Effect of Atomic Structure," by L. NORTHCOTT.

"A Study of Some of the Factors Controlling the Porosity of Hot-Tinned Coatings on Copper," by W. D. JONES.

"The Influence of Surface Alloying on the Strength of Soft Soldered Joints," by R. CHADWICK.

7 p.m. for 7.15 p.m.—Annual dinner and dance at Grosvenor House, Park Lane, W.1.

THURSDAY, MARCH 10.

10 a.m.-12.30 p.m.—The first award of the Institute of Metals Medal will be announced and the Medal will be presented. The following Paper will form the subject of a general discussion:—"The Training and Employment of Metallurgists," by R. S. HUTTON.

12.45 p.m.—Members who so desire will lunch together at St. Ermin's Restaurant (*table d'hôte* meal, 3s.).

Afternoon Visits

Two visits have been arranged for the afternoon of Thursday, March 10.—

Party A.—1.45 p.m., coach leaves St. James's Park Station, Broadway, S.W.1. 2.45 p.m., visit to the lamp and glass works of the General Electric Company, Limited, North Wembley. 6 p.m., coach due back at St. James's Park Station.

Party B (*limited to* 30).—2 p.m., train leaves St. James's Park Station for Gunnersbury. 2.45 p.m., visit to the Chiswick (bus) works of the London Passenger Transport Board. 5.30 p.m., train due back at St. James's Park Station.

Annual Dinner and Dance

The annual dinner and dance will be held for the first time at Grosvenor House, Park Lane, W.1. The price of tickets for the dinner, exclusive of wines, is 15s. Application for tickets may be made now by members who desire to reserve

(*Concluded in previous column.*)

Time and Motion Study in the Foundry

By C. D. POLLARD

(*Continued from page 88.*)

There are many and varied systems for working time and motion study schemes in the factories and works in the country, and the author will not make any attempt to compare the advantages or disadvantages of one scheme against another, but will confine himself to the working of the one with which he is in daily contact.

The work commences with the usual routine office work of entering the receipt of an inquiry for the price of castings, and the sales department make out an estimate sheet, which, along with the drawing and inquiry, passes to the drawing office for the preparation of what is called a layout sheet. The draughtsmen calculate the weight of the proposed castings and discuss with the foundry manager the suggested methods of coring, jointing, etc.

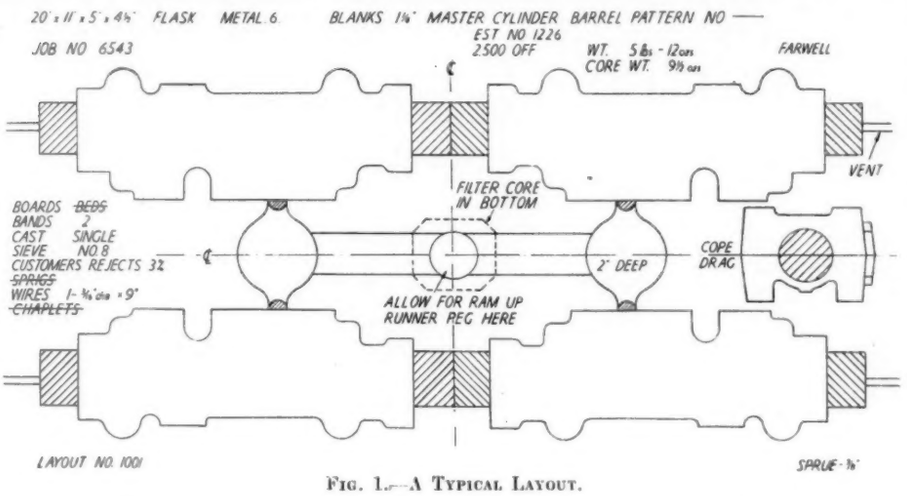


FIG. 1.—A TYPICAL LAYOUT.

The time and motion study men are then drawn into the discussion regarding those features of the job which affect the cost of production, such as how many patterns per box, type of moulding machine, flasks or moulding boxes, etc., and a rough layout of the job is prepared.

Fig. 1 shows a typical layout giving all the details which govern the working-up of the moulds for the job. Sizes of boxes or flasks, weight of core material required per casting, etc., are always given. This layout is submitted to the foundry manager for approval, and unless he wishes to make some alteration to the instructions shown thereon, he signs and accepts it as the most economical and efficient method of producing the castings in question.

At this juncture it is germane to mention and to emphasise that the figures used in the Paper to illustrate estimating and cost of production are fictitious, and are useless for comparison with any foundry's own figures.

It often happens that, at this stage, preliminary estimates are prepared for comparison in costs of more than one suggested method of manufacture. Fig. 2 illustrates examples of the advisability of this action, when more than one obvious method presents itself. It shows three alternative methods of production of moulds from normal pattern plant. On the left the job is laid out and estimated for on two hand-press machines, the operators being one man and a boy. In this case one completed mould is made in 541.4 seconds. The piecework price is 28s. per 100 castings, and the piecework standard per day is 46.5 moulds. Included in the figure, the same job is laid out and estimated for production on two jar rollover machines, involving as operators one man and a boy. One complete mould requires 530.9 seconds, and the piecework price is 27s. 6d. per 100 castings, and the standard per day is 46.6 moulds.

There is also included the job as laid out and estimated for production on two jar rollover machines. This involves the employment of two men, one machine making copes, and the other drags. The time per complete mould is 467 seconds, the standard per day is 55.41, and the piecework price 38s. 6d. per 100 castings.

This is a splendid example of the advisability in the early stages of estimating of weighing up the cost of different methods of production, as it shows how variables can influence figures to a far greater extent than is sometimes realised. It might be reasonable to assume that a man and boy with two power machines should get more production than they could get with two hand-ram machines, but there is evidence here that this assumption would be wrong.

Again, one might assume that two men with two power machines would give vastly improved production over either of the other two methods. One can certainly get nine more moulds per day, but at what a cost? The piecework price is high, on account of being based on high day-work rates, the machine rates per hour would also be high, and the ultimate price of the castings would probably be out of proportion to their value, at any rate too high to give a chance of getting an order for them.

Having obtained the foundry manager's signature for acceptance of the layout of the job, the inquiry, drawing, estimate sheet and layout sheet go to the time and motion study department, where the labour costs for all operations except patternmaking are calculated and put on the estimate sheet.

In this department a survey of the job is made and the operations considered necessary for doing the work are tabulated. Doubt sometimes arises, of course, as to whether some specific operation is necessary, and in such a case queries are sent or stated to the foundry manager, who decides whether or not he wishes to include the particular operation in question. For instance, the man who is estimating may be uncertain as to whether a mould should be vented or not, or whether a sprue should be cut or rammed up; these are only minor points probably, but if not cleared up and settled, they leave doubts as to pro-

ESTIMATE SHEET

Estimate No 10120

Estimated Customers Rejects %

Date of Order | Name and Address of Customer: Blanks Ltd. London. | No. of Castings: 1000 | Weight per Casting: lbs. 16 ozs. - | Total Weight: T. 7 c. 2 q. 3 lbs. 12

Blue Print No. | Description of Casting: Body Casting.

Core Cost. Per 100. Per cwt. s. d. s. d.
Wages .. 2 9·0 2·64
Waste 10% ·30
3·03
Bonus 70% 2·12
5·15
D.O.H. 150% 7·73
1-0·88

Moulding Cost. Per 100. Per cwt. s. d. s. d.
Moulding Wages 15 3·0
Pouring do. 2 6·0
Labouring do. 3 9·5
Waste 10% 11·6
21-11-1 1 5·52
Bonus 70% 1 0·31
2 5·89
D.O.H. 150% 3 8·84
G.O.H. 50% 1 2·93
7-5-68

Complete Cost. Per cwt. £ s. d.
Pig Iron No. 7 .. 7 6
Core Mixture .. 9·0
Dressing .. 1-5·8
Cores .. 1-0·9
Moulding .. 7 5·7
18 3·4
Customers Rejects 2% 18 7·8

Dressing. Per 100. Per cwt. s. d. s. d.
Grinders Wages 4 3·0 3·57
Bonus 75% 2·68
D.O.H. 150% 9·38
Filers' Wages 1 6·0 1·26
Bonus 70% ·88
Extras ..
1-5·77

Total Cost of Patterns .. .. Labour 7 Hours. .. £ s. d. 1·10·0

£ s. d.
12·10·0
1·10·0
14-0-0 per cwt. = 1/11·5 per each = 3·36

Cost per each .. .. .. £ s. d. 2-8

Total Estimated Cost at Works £ s. d. 133·6·8

Process: Iron in 26x14x6x6 Steel Box on Hand Press Cores.
No. of Cores per Casting — 2.
No. of Boxes per day 20·5.
Layout No. 10641

Actual Weight | lbs. | ozs.
Casting .. .. ..
Set of Cores .. ..

Actual Piece Rates per 100

	Job No. s. d.	Actual. s. d.
Moulders ..		
Pourers ..		
Labourers ..		
Cores		
Grinders ..		
Filers		

Signed

	Cost per cwt. £ s. d.	10 % £ s. d.	% £ s. d.	% £ s. d.
Freight	12·8	1·0·6½		
	1·7	1·7		
	1·0·3	1-2-1½		
Per each	2-10·72	3-1·9		
Annealed per each				

Date. | Price Quoted. | Remarks. | Delivery Quoted.

FIG. 3.—SPECIMEN OF ESTIMATE SHEET.

cedure if the order comes along at a later date. Having decided on the necessary operations, times are allocated to each one from the time and motion study records. Standard times may not be available for every operation, but usually, even on non-standard operations, some comparable records for similar work can be turned up. The job is then investigated to see what labour is most economical, *i.e.*, a man only, a man and boy, or a man and two boys, and so on, the decision being influenced to a large extent by the number of, and rates for, skilled and unskilled operations on the job. When this has been done the actual time per mould is obtained, and the costs per casting or per 100 castings are calculated and recorded on the estimate sheet.

The chief chemist gives information regarding the metal to be used.

The patternshop at this stage do their estimating, and it will be realised that as the method of production is definitely laid down on the layout sheet, the patternshop know exactly how the pattern plant is to be prepared. Thus variables in this direction are eliminated.

Passing from the patternshop to the costs department, where the overheads, freights, etc., are given, the inquiry finally is returned to the sales department with the complete estimate. All this sounds as though the estimating will take an alarming length of time, and the chance of getting an order is lost before the quotation is ready, but such is not the case, for with very few exceptions the quotations are posted within scheduled time.

Fig. 3 shows an estimate sheet specimen, which is almost self-explanatory. Spaces are provided for actual production figures to be inserted immediately the piecework rates are fixed, thus giving the sales office comparative figures whilst the job is in production.

This is a hurried survey of the process of estimating, and it will probably be agreed that variables are almost eliminated because the majority of the labour figures placed on the estimate sheet represent standard time allowances for the operations. The fact that the labour costs are analysed to such fine limits as quoting the number of shovels full of sand required per mould, and how many seconds it will take to handle that sand, other operations being covered in the same manner, assures that variables cannot easily find a way in at the estimating stage.

The only serious variable that exists is the choice of the method of making the job, but even in this, as already stated, when doubts and differences of opinion do arise, trial estimates are taken out to satisfy all concerned that the most economical and efficient method of manufacture is adopted from the various suggestions under consideration.

Dealing with Orders

Passing from estimating to the receipt of an order, the sales department issue to the works the necessary order-sheets, each pattern being given a separate works order number, which is used throughout the works and offices for booking and costing purposes. The layout sheet which was filed when the estimate was completed is now issued to the patternshop, and must be regarded as a direct and definite indication as to procedure in the pattern-plant preparation and moulding methods. The patternshop in due course issue the pattern plant to the foundry.

When a new job is going into production, the information is passed on to the foundry manager and the time and motion study department from the planning or progress department, who schedule the work in the foundry some days in advance. It is the duty of the time and motion study department to advise the foundry manager (or one of his assistants) what labour is required for the particular job, and whether the layout calls for one man only, one man and one boy, two men, and so on. Thus the foundry foremen, in conjunction with the progress department, can allocate their labour for any job, before the actual day on which it goes into production. As soon as the job is in work, an investigator from the time and motion study department goes into the shops to make a survey to ensure that all tools, etc., which are known to be necessary, are available, and easily accessible to the operators, in order to eliminate any waste

(*Continued on page* 108.)

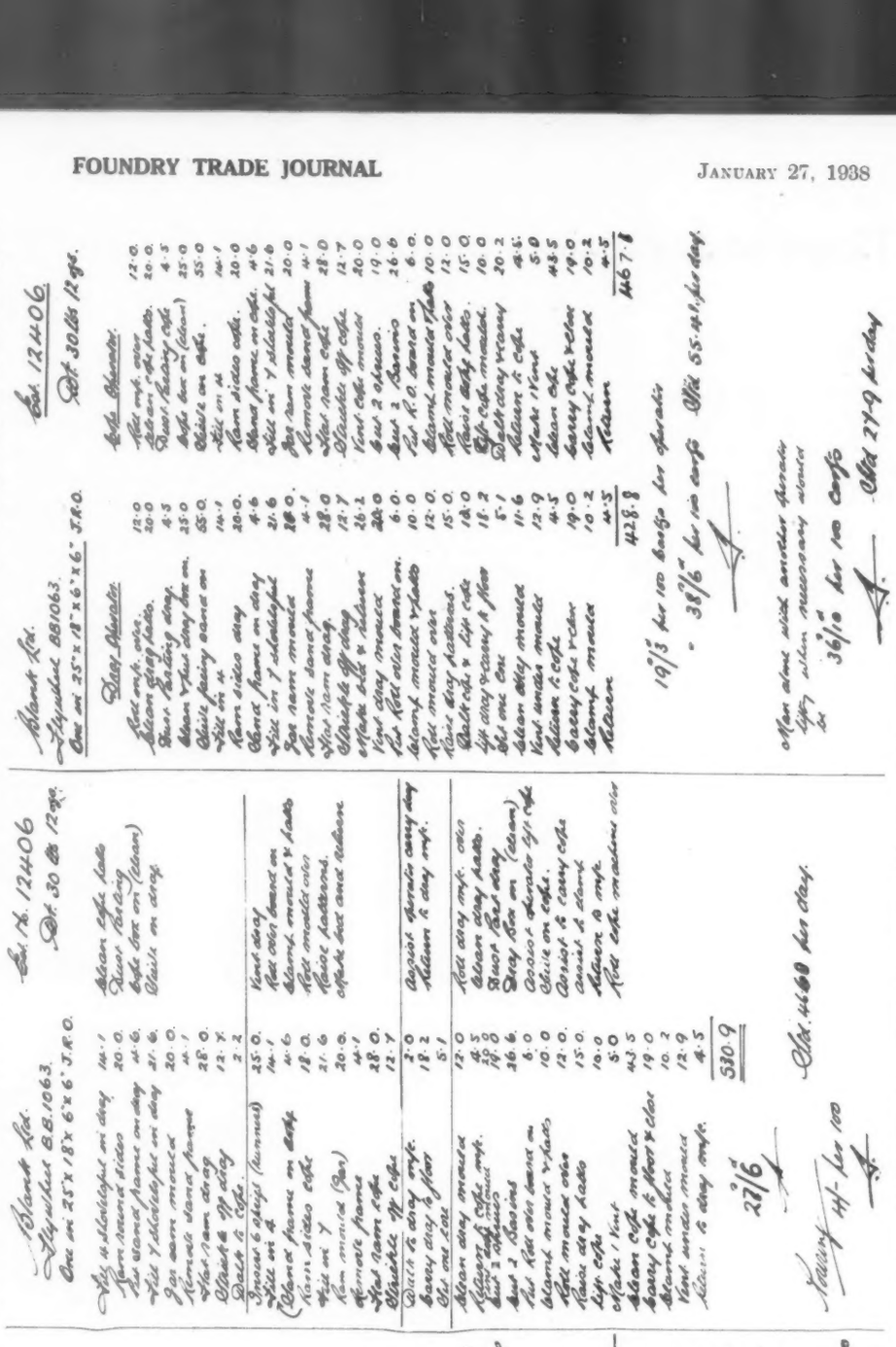


FIG. 2.—THREE PRELIMINARY ESTIMATES SHOWING ALTERNATIVE METHODS OF PRODUCTION.

Electrically-Melted High-Duty Iron

By V. A. CROSBY

The writer has read with considerable interest the report of Mr. B. MacDougall's Paper* to the Scottish Branch of the Institute of British Foundrymen on the subject of High-Duty Iron.

There are a number of important items covered in this article, some of which the present writer agrees with *in toto*, such as data shown in Table I, page 407; also, synthetic irons *versus* cupola irons of the same composition, shown in Table III, page 408. It is felt, however, that the conclusions drawn relative to the comparative effects of molybdenum and nickel in increasing tensile strength properties are worthy of further consideration.

This article, emanating from Mr. V. A. Crosby, of the Climax Molybdenum Company, of Detroit, Michigan, discussing Mr. MacDougall's Paper on High-Duty Cast Iron read before the Scottish Branch of the Institute of British Foundrymen, was submitted in the form of correspondence. Owing to its length, however, we have converted it into an article.

The writer notes that it was considered necessary to superheat in the case of the synthetic molybdenum irons to a temperature of 1,600 deg. C., because of the high melting point of the ferro-molybdenum. He disagrees with the essence of this statement since it assumes that melting point and solubility are one and the same. Pure molybdenum wire with a melting point of 2,537 deg. C. has been used for alloying purposes in molten cast iron at approximately 1,452 deg. C. with effective results. The wire was placed in the ladle, the metal was tapped in, and no stirring was required to effect solution and dispersion. The alloying of iron with ferro-molybdenum in percentages up to 1.00 per cent. Mo can be effected very successfully at temperatures of 1,454 to 1,500 deg. C. It is a personal opinion that the superheating temperature of 1,000 deg. C. was excessive and contributed largely to the comparatively poor properties of the molybdenum iron.

It has been personal experience that synthetic irons tend to go dendritic (with resultant eutectic graphite formation) more readily with similar degrees of superheating than cast iron of the same composition made from pig-iron. This explains, in part, why superheating may be beneficial to an iron carrying a large percentage of pig in the charge, while the same degree of superheating applied to a non-graphite-bearing charge would result in a dendritic structure and, therefore, failure to produce maximum physical properties.

Table I outlining physical properties is given to show the effect of superheating a synthetic iron of a high quality. For example, the effect of an additional 50 deg. C. of superheating is shown strikingly in the case of Heat 1228 *versus* Heat 1265. Although the compositions are quite similar and the irons have identical matrices, a remarkable difference in physical properties, due primarily to the character of the graphitic formation, is unmistakably evident. It will be observed that Heat 1299 contains no alloys but, being properly made and securing the right type of graphite, this material compares very favourably with Heat 1228, which is highly alloyed but failed to develop maximum strength because of too high superheat.

A comparison of Nos. 1299 and 1265 shows the advantages of alloys in an iron properly made in both cases. A comparison of No. 1265 with No. 1266 shows the contribution of nickel to the physical properties of a molybdenum iron. Heat No. 1305 is given to show the comparative effects of copper-molybdenum iron with plain molybdenum and nickel-molybdenum irons of similar base composition. All of the irons shown in Table I were made in an electric furnace of the induction type holding 30 lbs. of metal.

Unfortunately, Mr. MacDougall does not offer an unetched micrograph of any of the molybdenum irons, although heat No. 59, a nickel-molybdenum iron, does show a normal graphitic structure. It is possible, however, that the addition of 1.8 per cent. nickel (a graphitising agent) has facilitated the formation and development of a normal graphite. It is also believed that the molybdenum irons referred to in Table VIII of the original Paper would reveal a graphitic distribution similar to that shown in Fig. 19, heat 18 R, and, because of this type of graphitic structure, disappointing physical properties have resulted, especially in the higher strength irons. It is quite true that in irons ranging from 14 to 18 tons per sq. in., the presence of a dendritic pattern may have little effect on tensile and transverse strength, although dendritic formations most assuredly exert their influence in higher strength irons of 22 tons and upwards. Moreover, deflection values of all irons are invariably lower than for normal graphitic patterns.

The above statements are offered as an explanation of the findings of Mr. MacDougall, as stated on page 411: "It would seem that the higher tensile strengths ranging in this series of experiments are more a function of the nickel content than the molybdenum content."

Relative to the author's (Mr. MacDougall's) conclusions concerning the apparent negligible effect of molybdenum in quantities up to 0.50 per cent., the writer submits in Tables II and III data showing the progressive improvement in tensile properties of cast iron with increasing amounts of molybdenum.

All of the irons shown in Tables II and III had normal graphite structures and pearlitic matrices. For this reason, no micrographs are submitted. When these fundamental findings are not substantiated with Mo additions up to 1.0 per cent., personal experience has been that there are other factors present which are of greater importance than the alloy additions.

TABLE II.—*Electric Furnace Irons.*

No.	1	2	3	4	5
T.C, per cent.	3.31	3.31	3.27	3.24	3.27
C.C "	0.70	0.70	0.72	0.70	0.83
Gr "	2.61	2.61	2.55	2.54	2.44
Si "	1.81	1.83	1.89	1.79	1.90
Mn "	0.84	0.84	0.86	0.83	0.88
S "	0.087	0.080	0.09	0.08	0.09
P "	0.159	0.161	0.15	0.15	0.17
Mo "	—	0.29	0.63	1.03	1.41
Tensile, tons per sq. in.	18.75	20.5	22.9	24.4	27.3
Brinell hardness	217	223	228	241	269

TABLE III.—*Cupola Irons.*

No.	1	2	3	4	5
T.C, per cent.	3.31	3.27	3.23	3.23	3.26
C.C "	0.57	0.63	0.61	0.67	0.71
Gr "	2.74	2.64	2.62	2.56	2.55
Si "	2.02	2.02	1.96	1.93	2.06
Mn "	0.67	0.67	0.63	0.73	0.76
S "	0.12	0.12	0.11	0.10	0.10
P "	0.18	0.18	0.17	0.17	0.17
Mo "	—	0.11	0.23	0.36	0.55
Tensile strength, tons per sq. in.	15.6	17.4	18.7	19.6	20.5
Brinell hardness	207	212	217	228	248

TABLE I.—*Physical Properties of High-Duty Irons.*

Heat No.	1228	1299	1265	1266	1305
Total carbon, per cent.	2.62	2.50	2.49	2.50	2.46
Combined carbon "	0.60	0.60	0.66	0.65	0.64
Graphitic carbon "	2.02	1.90	1.83	1.85	1.82
Silicon "	2.50	2.82	2.71	2.80	2.59
Manganese "	1.11	0.98	0.97	0.99	1.06
Molybdenum "	1.00	—	1.03	1.04	1.00
Nickel "	1.05	—	1.01	—	—
Copper "	—	—	—	—	1.06
Superheating temp., deg. C.	1,537	1,482	1,482	1,482	1,482
Pouring temp., deg. C.	1,454	1,454	1,454	1,454	1,454
Transverse test (1.2 × 18 in.), lbs.	3,365	3,806	5,410	4,510	4,025
Deflection in ins.	0.241	0.280	0.570	0.415	0.320
Brinell hardness No.	325	285	331	302	352
Tensile (0.800 in.), tons per sq. in.	23.4	31.1	35.9	33.1	36.4
Impact (1¼-in. rd., 6 in. centres), ft.-lbs.	35	—	106.9	118.1	—
Transverse (2.0 × 24 in.), lbs.	12,000	13,790	16,800	17,100	16,200
Deflection in ins.	0.227	0.333	0.470	0.455	0.392
Brinell hardness No.	293	255	302	286	302
Tensile (0.800 in.)	26.5	24.4	29.2	33.4	30.1
Impact (1¼-in. rd., 6 in. centres), ft.-lb	46.9	44.4	120.+	113.1	120.+
Group No.	1	2	3	4	5
Photomicrograph plate Nos. (See pages 104 and 105.)	3,468 3,476 3,472 3,480	3,706 3,720 3,713 3,727	3,600 3,610 3,605 3,615	3,601 3,611 3,606 3,616	3,712 3,726 3,719 3,733
Matrix	Acicular	Pearlitic	Acicular	Acicular	Acicular
Type of graphite	Eutectic	Normal	Normal	Normal	Normal

* FOUNDRY TRADE JOURNAL, November 25, 1937, pp. 407-412.

FIG. 2.—THREE PRELIMINARY ESTIMATES SHOWING ALTERNATIVE METHODS OF PRODUCTION.

Group 1. (Heat No. 1228)

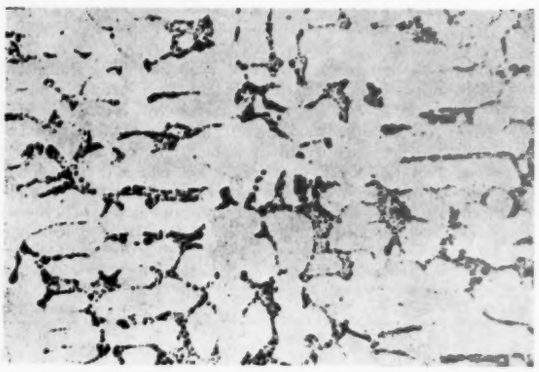


PLATE NO. 3468. 1.2 IN. TEST-BAR. UNETCHED. × 100.

PLATE NO. 3476. 1.2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

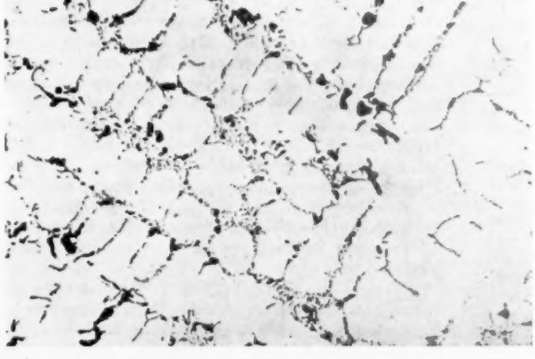


PLATE NO. 3472. 2 IN. TEST-BAR. UNETCHED. × 100.

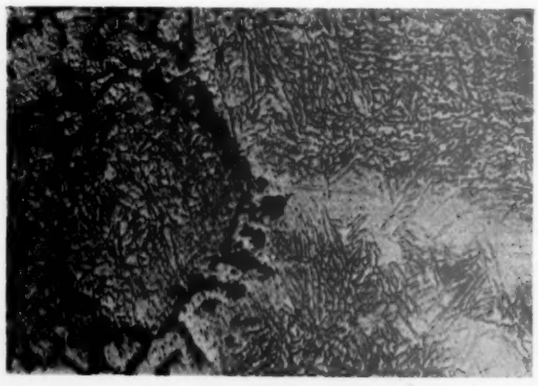


PLATE NO. 3480. 2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

Group 2. (Heat No. 1299)

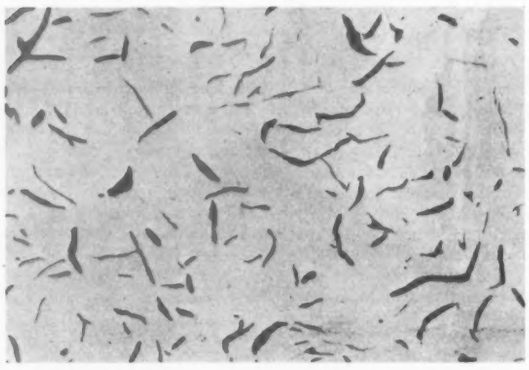


PLATE NO. 3706. 1.2 IN. TEST-BAR. UNETCHED. × 100.

PLATE NO. 3720. 1.2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

PLATE NO. 3713. 2 IN. TEST-BAR. UNETCHED. × 100.

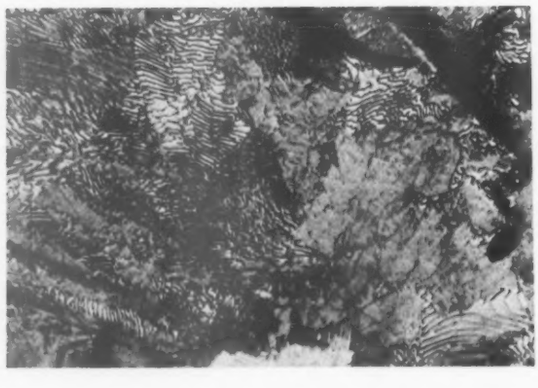


PLATE NO. 3727. 2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

Group 3. (Heat No

PLATE NO. 3600. 1.2 IN. TEST-BAR

PLATE NO. 3610. 1.2 IN. TEST-BAR. NITAL. × 500

PLATE NO. 3605. 2 IN. TEST-BA

PLATE NO. 3615. 2 IN. TEST-BAR. NITAL × 50

. (Heat No. 1265) **Group 4. (Heat No. 1266)** **Group 5. (Heat No. 1305)**

IN. TEST-BAR. UNETCHED. × 100.

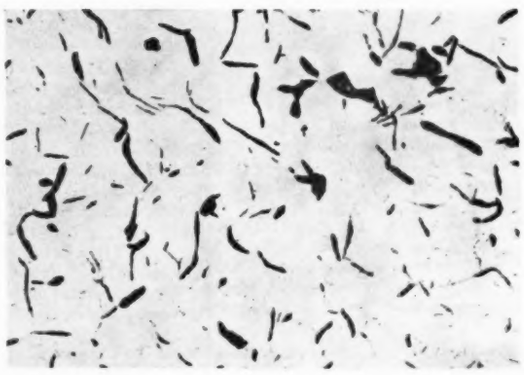
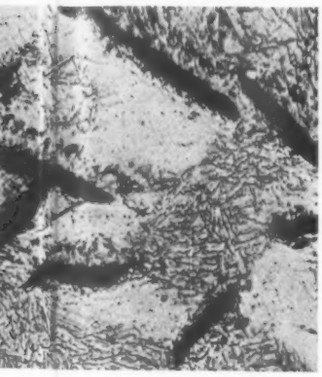


PLATE NO. 3601. 1.2 IN. TEST-BAR. UNETCHED. × 100.

PLATE NO. 3712. 1.2 IN. TEST-BAR. UNETCHED. × 100.



IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

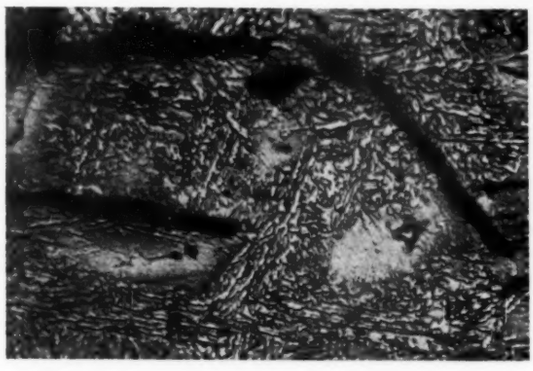


PLATE NO. 3611. 1.2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

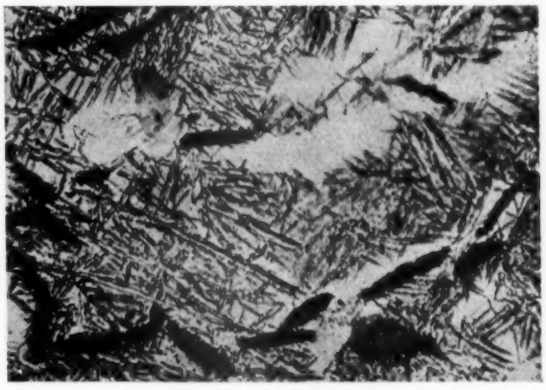


PLATE NO. 3726. 1.2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

2 IN. TEST-BAR. UNETCHED. × 100.

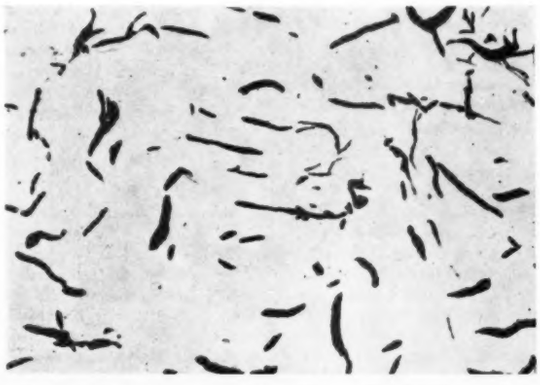


PLATE NO. 3606. 2 IN. TEST-BAR. UNETCHED. × 100.

PLATE NO. 3719. 2 IN. TEST-BAR. UNETCHED. × 100.

IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

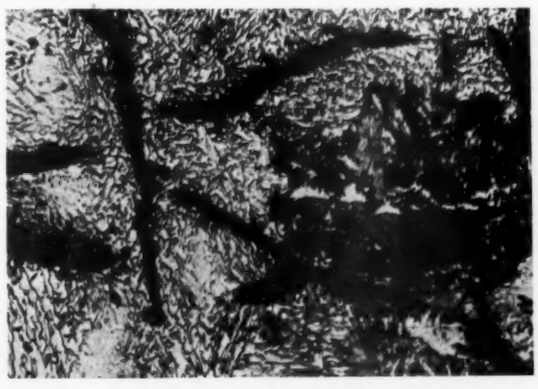


PLATE NO. 3616. 2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

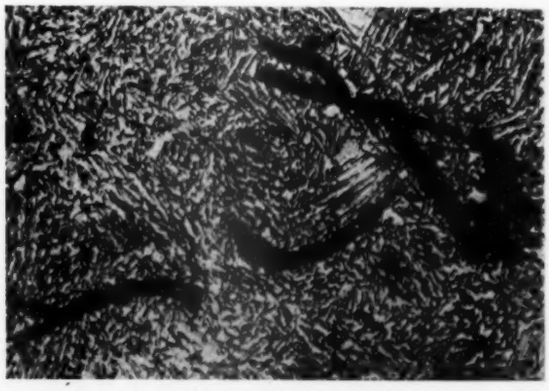


PLATE NO. 3733. 2 IN. TEST-BAR. ETCHED 2 PER CENT. NITAL. × 500.

Refining Steel in the High-Frequency Furnace

Following the presentation of Mr. Victor Stobie's Paper on "Refining Steel in the High-Frequency Furnace"* to the Scottish Branch of the Institute of British Foundrymen, MR. EVAN J. ROSS (Branch-President) observed that the author had dealt with a subject which to many members would seem to be outside the ordinary scope. They were not usually electrical engineers as well as foundrymen; but Mr. Stobie had been so lucid that, with the aid of the illustrations, one could easily follow what happened in the high-frequency furnace. The electric furnace was not as well known as other types of furnaces in foundry work, but it was obvious that control could be easily held within narrow limits.

Removal of Elements

MR. B. MACDOUGALL said that, when refining in a three-phase arc furnace, there was a certain temperature at which refining began, and he would like to know whether there was a similar temperature in the high-frequency furnace. In regard to the elimination of carbon and phosphorus, could Mr. Stobie say whether they were eliminated together or whether the carbon went first, followed by the phosphorus.

MR. STOBIE said that, so far as the temperature at which refining began was concerned, he would say some reactions with slag would start immediately the metal was plastic, and slight ones even earlier. It was known that when molten steel was setting, any FeO present could react with carbon and sparks be thrown off; so refining reaction could occur at quite low temperature. On the other hand, the higher the temperature of refining, the more certain was the carbon to be diminished before some other elements. With CO-saturated atmosphere and slag he would say the rough order was: silicon, manganese, carbon, phosphorus; but this would depend on the precise conditions. He had not ascertained the temperatures at which each constituent left the bath.

Fundamental Differences

MR. MACDOUGALL explained that he wanted to know where to hold the bath at the best refining stage as regards temperature. In the arc furnace he found it necessary to hold at a definite temperature, which was accomplished by keeping the current consumption at a fixed quantity—in his own furnace 90 or 75 kw.

MR. STOBIE replied that, in the present furnace, refining proceeded so rapidly that the current was kept on full until near the end of the refining stage. Additions of ore were made as soon as the charge and slag were molten. When the carbon was reduced to 0.02 per cent., the refining slag was poured off and replaced by a finishing one. In the arc furnace refining was, by comparison, very slow. There was not the same outlook in operating with the refining high-frequency furnace as with the slower working furnace; otherwise the advantage would be lost.

MR. EVANS, referring to the table of results which Mr. Stobie had given, said the sulphur content was given as 0.03 per cent. in most heats. He thought that was poor working. In the arc furnace the slag was hotter than the steel under it, and it was easily possible to reduce sulphur to 0.02 per cent. He maintained that if desulphurising was required there must be a combination of high temperature and high lime content.

MR. STOBIE suggested that Mr. Evans had not looked completely at the figures he had given. The sulphur of the later heats reached the 0.02 per cent. category. He had not aimed at getting such low-sulphur figures as were sometimes reported abroad from high-frequency furnaces after using freak slags with sodium and potassium salts. There was not much purpose in getting sulphur down to traces merely for the sake of saying it had been done. He considered there was a commercial advantage in reducing the sulphur to a desired figure by oxidation at low temperature rather than by the high heat required in the arc furnace. The new furnace did so well that there was no object in forcing an imitation of other furnace processes. If less than 0.02 per cent. sulphur was required for some special reason, then perhaps they might use an arc furnace.

MR. EVANS said Mr. Stobie used to advocate the use of a falling slag, and he maintained that it was impossible to get sulphur out unless they did have a falling slag. He thought it was necessary to reduce sulphur to 0.02 per cent.

MR. STOBIE said that, in the case of an arc furnace, to reduce sulphur one must use a falling slag. In the refining high-frequency furnace such slags, though easily obtainable, were unnecessary, and he had not used them on the heats in question.

Acid and Basic Linings

MR. KIRBY said that when Mr. Stobie first started with electric furnaces he used an acid lining in his experiments, but he now used basic linings. Could he state what difference there was in the working of an acid or a basic lining? What was the relative life of the two kinds of lining?

MR. STOBIE replied that he could hardly compare the relative life of the linings of an acid furnace not refining with a basic lining refining. The acid-lined ordinary high-frequency furnace was highly satisfactory for some purposes, such as the plain melting of alloy steel. High nickel-chrome alloys were melted more successfully in an acid-lined than in a basic-lined ordinary furnace. Carbon could be reduced in the acid-lined refining high-frequency furnace, and if very high chrome were present with the carbon the acid-lined refining furnace would be the more advantageous for carbon reduction.

MR. ROBERTON said that apart from the type of furnace used, carbon and other elements were removed by oxidation, and that inferred the presence of oxygen in the metal. The time the metal was in the furnace before tapping must be the time required to remove the oxygen. In the high-frequency furnace Mr. Stobie stopped just before refining was complete. He made no additions except ferro-silicon and alloys. He thought that the oxidation of the ferro-silicon must give particles of silica in the steel. Was the steel from this furnace clean and free from siliceous solutions?

The Finishing Process

MR. STOBIE pointed out that the surface of the metal under the slag was small in comparison with that of arc and open-hearth furnaces, and the weight of the slag was therefore relatively small. In other refining furnaces there was a heavy mass of slag controlling the operation and it was necessary to adjust it by, figuratively, slow motion, which meant more expense and less output. In the refining high-frequency furnace only the ending of refining proceeded slowly. The steel contained some residual iron oxide after refining, but the slag was poured off and ferro-silicon put on top of the metal before the next slag. No ferro-manganese was added to the heats dealt with in the Paper for reasons unrelated to the refining. The furnace was tapped about 10 minutes later. Providing the finishing of a steel was correctly conducted, and that was the focus of the steelmaker's skill, it was usually found that a bath which had been sufficiently fed with iron oxide during refining produced a finished steel freer from slag inclusions than when the additions of oxide more nearly approached theoretical requirements.

Sulphur Reduction

DR. R. HUNTER said he was rather disappointed to observe the relatively high sulphur content of the refined steels shown in the table. In electrically-melted steel one expected to find a sulphur content of under 0.02 per cent. The charges enumerated at the top of the list had a sulphur content of over 0.02 per cent., whereas in those towards the foot it had fallen to below this figure. Was this due to an alteration in the method of refining or merely fortuitous? The processes of sulphur and phosphorus reduction were in general opposed in respect of the most favourable degree of oxidation, and he wondered if any special experiments had been made in regard to a final slag having a high sulphur solubility. Most foundrymen were particularly interested in a steel suitable for mild-steel castings having a carbon content of generally 0.20 to 0.25 per cent. With this refined steel at his disposal how would Mr. Stobie introduce the required amount of carbon?

MR. STOBIE reiterated that it was true that the later heats showed a further drop in sulphur contents, which was certainly not due to fortuity but to increased experience. Even had they been fortuitous, the furnace would still have had the credit, but not so the operating skill of the melter. They were working mainly to obtain a low carbon content, and it was clear that some extra sulphur was oxidised by a changed routine of oreing in the later heats. They aimed at dead low carbon, silicon, manganese and phosphorus, and he could say they had mastered the process to that extent. He had not seriously tried sulphur removal by a falling slag. If lime demanded the high temperature of the arcs in an arc furnace for the ultimate production of a sulphide in the slag, it would be useless trying to reduce the sulphur below 0.02 per cent. by a falling slag in the refining high-frequency furnace; but he did not consider that a final pronouncement. In some Continental practice alkaline salts were added to the slag to reduce the sulphur to 0.01 per cent. or less. He might try to imitate the arc later, but its advantage was not apparent at present. In regard to recarburisation, he had not used anthracite in the refining furnace.

Melting Highly-Alloyed Steels

MR. EVANS, referring to the melting of alloys of chrome, aluminium, etc., stated that as aluminium was so searching it was probable that a very bad bottom would result. He referred, of course, to the melting of high proportions of chrome-aluminium scrap.

MR. STOBIE said he appreciated Mr. Evans' point. If one could not melt the material in the furnace, one should put it aside. In the case mentioned it was not necessary to refine, and he would recommend an acid-lined furnace.

MR. EVANS said it would be necessary to have a falling slag and there would be a loss of chromium.

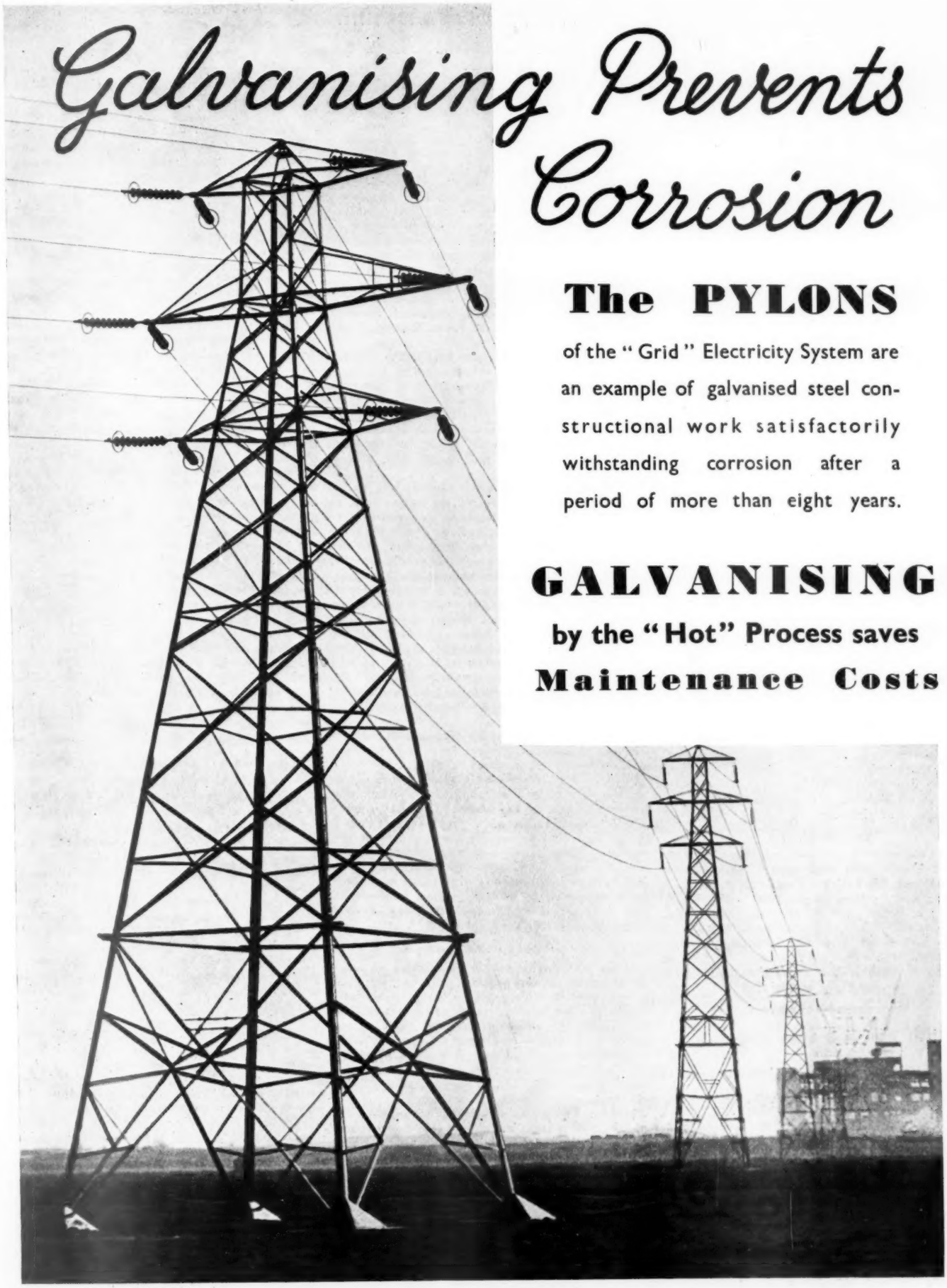
MR. STOBIE pointed out that the majority of high-frequency furnaces, melting alloys of the 18-8 type, were acid lined, and he could not see why an acid-lined arc furnace should not be used for that material if no refining were required.

Operating Times

MR. JAMES MILLER said that they had heard a good deal about the analyses of the material during the discussion, but he would like to speak from another angle. The design of the furnace which Mr. Stobie had shown differed considerably from the furnaces which he had seen, and it had interested him very much. He would like to know what quantity of metal it was possible to melt in the twenty minutes which Mr. Stobie had mentioned. What was the thickness of the lining usually employed? In adding the alloy

* FOUNDRY TRADE JOURNAL, December 23, 1937, pp. 489-491.

Galvanising Prevents Corrosion



The PYLONS

of the "Grid" Electricity System are an example of galvanised steel constructional work satisfactorily withstanding corrosion after a period of more than eight years.

GALVANISING

by the "Hot" Process saves

Maintenance Costs

the cover was lifted, and he was wondering how much heat would be lost in the operation. Personally he regarded Mr. Stobie as a known authority on the subject and accepted his statements proving the furnace efficiency.

MR. STOBIE thought perhaps he had not been sufficiently explicit, because he did not wish to suggest that he melted in 20 minutes. The time of refining was from 20 to 40 minutes, but there was 40 minutes or more before that occupied in the melting of the charge. He could not say how much heat was lost. It was not possible to avoid losing some heat in raising the roof of a small furnace, but larger plant did not require the removal of the roof.

MR. BROTHERTON said that, comparing the mass of refractories in the old and new forms of the furnace—the latter must have three times the bulk—there must be a very much larger heat loss on that account. There would also be a large loss of heat in charging when the cover was off. He thought that if the thermal efficiencies of both were considered the balance would be in favour of the old type.

MR. STOBIE replied that one could not examine a furnace balance sheet of thermal efficiency without being able to criticise calculations in many respects; all depended on the bases adopted. Reasonable weight of insulating refractory surely had the considerable advantage of better retaining the heat, and not of wasting it. He did not necessarily remove the roof for charging, but in some cases it was advantageous to do so. The roof also remained on for tapping.

MR. HAMILTON said that the slags given by Mr. Stobie would be altogether unsuitable in the high-frequency furnace with a basic lining as the crucible would not withstand their cutting action. Was there any slag, fluid or otherwise, which would give a reasonable life to a basic lining, for contrary to Mr. Stobie's experience, he had a slag in use which allowed a basic lining to give as good, if not better results than an acid one, as far as heats per lining were concerned.

MR. STOBIE said that was exactly the subject he had been talking about and the reason for the modernised furnace. He raised the slag-line right on to thick and tapered banks well above the furnace coil, instead of having it at the place of maximum crucible temperature and within two or three inches of the electrical winding. No refining lime slag could be be suitable in the old type of high-frequency furnace, which was only capable of plain melting.

Vote of Thanks

The CHAIRMAN, in proposing a vote of thanks to Mr. Stobie, said that probably the subject of the Paper was entirely new to many members present, and to those acquainted with electric melting it would have been particularly useful. The discussion indicated that even the latter parties had found some new features. He felt sure there would be no hesitancy in making plain to Mr. Stobie how much they had appreciated his visiting them and giving the Paper.

British Iron and Steel Federation

The British Iron and Steel Federation announces that Sir Thomas Inskip, M.P., Minister for the Co-ordination of Defence, and Mr. W. S. Morrison, M.C., M.P., Minister of Agriculture, will be the principal guests at its annual banquet at Grosvenor House on March 17. Viscount Greenwood, chairman of Dorman, Long & Company, Limited, who is President-elect of the Federation, will preside at the banquet.

Ships Sold for Scrap

Less than 400,000 tons gross of world shipping (excluding American) was sold for demolition purposes during the year 1937, this being the lowest level touched for many years past, says a review in "Lloyd's List and Shipping Gazette."

Recovery of Vanadium from Cupola Slags

(FROM A CORRESPONDENT.)

A few years ago wide publicity was given to the advantages which would accrue from the addition of soda ash to cupola charges during the melting of iron. This was done with a view to reducing the sulphur content, and ensuring that a more uniform type of metal would be produced. As the various alkali firms possessed abundant supplies of soda ash, little difficulty was experienced in more or less eliminating the impurity at comparatively little cost. A metallurgical works in South Russia has substituted common salt for the soda ash. The lining of the cupola was expected to become unduly corroded, but in practice did not show any serious effects. Much of the salt volatilised, however, and was frequently to be found deposited near the furnace top.

As crude rock salt abounded in the district, the cost of this treatment was trifling compared with that of using soda ash, despite the small amounts required, but the Russians were not content with merely separating the sulphur. One of the most important metals required for the production of special steels is vanadium, and a similar method had earlier been applied to blast-furnace work.

The use of common salt is more or less limited to hearths where a blast of air passes over, or through, the molten metal, as it appears to be only when sufficient oxidation occurs that the vanadium becomes absorbed by the flux. In this country it is known that methods were attempted in the open-hearth, but without much success. When the pig-iron contained a minute proportion of this valuable constituent various alkaline fluxes were charged, but the recovery was disappointing, and was later attributed to the absence of the necessary oxidation. Until quite recently, converter practice in this country had been reduced to a minimum, and thus the potential value of purchased pig-iron containing vanadium, titanium and other rare impurities became lost.

The practical point which did much to militate against the use of these fluxes with air-blast furnaces was the manner in which they were dissipated into the atmosphere. With an abundant supply of rock salt however, the cost was trifling. Much of the ordinary cupola practice entails the addition of a surplus of "shop" scrap, pig-iron representing the minority of the charge. Thus it is seldom considered worth special slagging attention. Where the best castings have to be produced, large pig-iron charges have sometimes to be used almost exclusively, and it is on such occasions that the fluxing system may be taken advantage of.

The Wet Coke Theory

Those who have had the advantage of close attention to cupola practice will be aware of the manner in which certain damp cokes will supply greater heat than the same material in dry condition, although perhaps contrary to ordinary established practice.* The damp coke is more compact, and this may be checked by throwing lumps into a pail of water, when the damp pieces will sink, whereas the dry coke will float.

After a thorough investigation it was ascertained that a smaller charge of fuel (taken on the original dry weight) would suffice, and this introduced a distinct economy. There is, of course, a point where excessively soaked coke will fail to ignite properly, and thus any wetting of the fuel must not be done in haphazard fashion. Now in charging common salt, it was found that by impregnating the coke before use, volatilisation losses could be reduced to a minimum, *i.e.*, as compared with charging common salt independently. Salt possesses the unwelcome property of absorbing moisture from the atmosphere, as all operatives acquainted with pulverised coal experiments are aware. Hence, although the coke may be left to dry after impregnation, this will but rarely obtain except in dry weather.

* This point is still debatable.—Editor.

Salt-Impregnated Coke Used

The coke being heavier per unit, and being charged on a weight basis, thus follows the foregoing means of economy. The pig-iron containing vanadium and titanium is simply charged into the cupola between definite layers of the salt-impregnated coke. These layers are measured from the charging door by means of a piece of flat iron suspended from an iron chain, so as to ensure their uniformity. When the blast is made to impinge on the hot coke, the flames are immediately yellow resulting from the presence of sodium salts, but otherwise no difference is experienced.

The slag is more easily fusible, but tends to produce a form of stickiness unknown to sodium-free slags. Metallurgists who have already dealt with such slags will be aware that, when a certain proportion of sodium is exceeded—in keeping with the respective contents of silica, lime, iron oxide and alumina—a thin layer of more fusible slag will rise over the surface of the remainder.

In making a certainty of this system, it is important to follow the respective specific gravities, since should the most fusible material be heavy, then no upper independent layer will be given the opportunity to form. In such a case any recovery work is handicapped by the necessity of crushing the whole of the slag.

When the foregoing layer system is followed, even although the vanadium content may be of the most trifling order, it becomes a simple matter to concentrate it in the topmost layer. These layers are accumulated, when an analysis will reveal that practically the whole of the vanadium has been concentrated in small bulk, and now obtains to a definite percentage, sufficient to justify the usual extraction methods being applied. The latter need not be elaborated upon, as literally a small library of works has been published on the recovery of this metal.

Time and Motion Study in the Foundry

(*Continued from page* 102.)

of time or energy on their part whilst they are at work.

The investigator then discusses the various operations with the manager or foreman and the operators, with a view to eliminating unnecessary work, and trials are carried out to prove that, by the methods adopted, satisfactory moulds can be made from the pattern plant in use. The investigator now makes a more detailed motion study whilst the work is going on, and allocates the less skilled operations to the assistant operator (except, of course, in cases where one man is making complete moulds) in such a manner as to synchronise the movements on cope and drag parts.

This is not exactly a matter of trial and error, as the data in the files of the time and motion study department give sufficient information to control these allocations, but it is to the advantage of the operators and the investigator to prove the allocations, and adjust them where advisable on every job, because where two or more operators are working together, they must attain a balance of movement which amounts to rhythm and results in 100 per cent. efficiency.

From the time the job is put into production until this stage is reached, the vital work of the investigator is carried out, and in the majority of cases it occupies far longer than the actual time study. When the operators have settled down and are working smoothly, the investigator proceeds with the time study.

(*To be continued.*)

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The Week's News in Brief

Trade Talk

THE STRENGTH of the engineering skilled labour force of South Africa was augmented during 1936 by the immigration of 854 artisans.

HUGHES BOLCKOW SHIPBREAKING COMPANY, LIMITED, Blyth, have received the French liner "Lutelia" (14,654 tons) for breaking up.

MEMBERS OF the Metallurgical Department of the Sir John Cass Technical Institute, London, are to visit a number of works in Sheffield during the week commencing May 9.

ACCORDING TO THE "Engineer and Foundryman" (South Africa), it is rumoured that a large foundry is to be opened in the East Rand with British [United Kingdom] capital.

THE £22,000 TENDER of Cochrane's (Middlesbrough) Foundry, Limited, for the supply of pipes for the water supply scheme of Debenham (Suffolk) Rural Council, has been accepted.

THE STOCK EXCHANGE COMMITTEE announces that as I.C.I. (General Chemicals), Limited, has been converted into a private company, permission to deal in the shares has been withdrawn.

COKE & GAS OVENS, LIMITED, London, has received an order from the Lancashire Foundry Coke Company, Limited, for 15 ovens, together with condensing plant, this being the fourth battery that they will have erected for this company.

MR. VICTOR MOYLE, foundry proprietor, of School Road Foundry, Hampton Wick, Kingston-on-Thames, has sent us a selected telephone number reminder card for hanging near the apparatus. It is particularly useful in London, owing to the gargantuan dimensions of the area directory.

THE COVENTRY MACHINE TOOL WORKS, LIMITED, have booked an order for what is believed to be the largest horizontal forging machine ever built in this country. Weighing over 100 tons, the new machine will forge steel bars of considerably larger size than any previously handled by machines of British make.

THE GENERAL ELECTRIC COMPANY, LIMITED, and Babcock & Wilcox, Limited, have been awarded contracts worth £830,000 for Johannesburg's new power station. The turbo-alternators will be built at Whitton (Birmingham) and Erith (Kent), and the boilers will be made at the Renfrew works of Babcock & Wilcox, Limited.

THE VICE-CHANCELLOR of Cambridge University has announced that the Iron and Steel Industrial Research Council has approved a grant of £500 being made by the Alloy Steels Research Committee for 1938 for research on corrosion fatigue. The work will be under the direction of Dr. U. R. Evans. It is intended to renew the grant next year.

RAINFALL OVER Kinlochleven in January has been more normal, and as a result the Blackwater Dam has risen to a height of 36 ft. Production of aluminium at the British Aluminium Company's factory was increased by the restart of another series of furnaces on January 18. Large extensions are being made to the Lochaber works, and when completed production of metal will be almost doubled.

MR. ROBERT R. HYDE, director of the Industrial Welfare Society, is anxious to obtain details of any voluntary efforts made by individual firms who have already granted holidays with pay, to provide facilities for their employees' holidays, and invites employers who may be willing to do so, to send a note about their holiday schemes to the Industrial Welfare Society, 14, Hobart Place, Westminster, S.W.1.

WITH A VIEW to investigating the possibilities of extracting iron from slag heaps in the area, a party of German engineers have arrived on Teesside and have made their headquarters at Teesport in a row of old Army huts. Some years ago Dorman, Long & Company, Limited, considered a similar scheme, but it was thought then not to be an economic scheme. Owing to the present demand for materials it is believed the suggestion may now be more feasible.

THE DEMAND FOR SPECIAL STEELS in Japan is very heavy, and makers in that country are covered for many months forward. Imports are becoming increasingly difficult and are expected to cease by the end of this month. Prices have been steadily appreciating and high-speed steels are now four times dearer than they were a year ago. Drill steels have nearly doubled in price, as the import duty is higher than the previous market price. Stainless steels have advanced 25 per cent. in cost.

CORRESPONDENTS IN South Africa have drawn the attention of the Federation of British Industries to the necessity for British firms making sure that all mail for South Africa is properly stamped. Since the inception of the arrangements under which all first-class mail for Empire countries in East and South Africa is carried by air at the rate of 1½d. per half ounce and no longer per ounce, many letters and letter-packets have been received by South African firms which have been prepaid at the old rate. This is a matter of considerable annoyance to the addressees, who are called upon to pay surcharge of double the amount of the deficient postage. In one case reported to the Federation the addressee was surcharged 12s. 6d., and in another case 8s. 6d.

Personal

DR. GUIDO VANZETTI has changed his address from Via Bianca di Savoia, 10, to Corso Venezia, 73, Milan, Italy.

SIR ARTHUR AITON, governing director of Aiton & Company, Limited, pipe founders, of Derby, is now on a visit to South Africa.

MR. J. N. ST. GEORGE CURWEN, of Papcastle, Cockermouth, has joined the Board of the Workington Iron & Steel Company, Limited.

AFTER NEARLY 30 years' service with the British Aluminium Company, Limited, at Kinlochleven, Mr. Donald MacDougall, transport foreman, has just retired. He was appointed to the transport department in 1911, and took a leading part in the reorganisation of the department.

PROF. WILLIAM JOHN GOUDIE has resigned from the James Watt Chair in the Theory and Practice of Heat Engines in Glasgow University. His resignation has been accepted with regret by the University Court. In 1921 an endowment of £30,200, raised by the Institution of Shipbuilders and Engineers in Scotland as a memorial of the centenary of the death of James Watt, was partly utilised in founding the Chair of Heat Engines. Prof. Goudie has been the only occupant of the Chair since its foundation.

MR. A. S. HUXLEY, general manager of the South Wales sheet works of Richard Thomas & Company, Limited, has resigned in order to take over the managing directorship of the steelworks at Haulbowline, Ireland. Mr. Huxley has been at Ebbw Vale for 25 years, and became manager of the sheet mills when they were erected. He will have among his co-directors Mr. A. W. Kieft, a former joint managing director of Richard Thomas & Company, Limited, and Major J. M. Bevan, chairman of the Briton Ferry Steel Company, Limited.

Wills

BIRTWISTLE, ROBERT, of St. Annes-on-Sea, ironfounder	£31,279
JONES, E. A., chief engineer of the Llanelly works of Richard Thomas & Company, Limited	£8,945
HAMILTON, LT.-COL. J. W., formerly chairman of William Hamilton & Company, Limited, shipbuilders, Port Glasgow	£135,855

Obituary

MR. C. W. FINDLAY, chairman and managing director of the Glacier Metal Company, Limited, has died.

MR. JAMES D. D. MACINTYRE, for many years assistant secretary with Stewarts and Lloyds, Limited, Glasgow, died recently, at the age of 47.

MR. JOSEPH BARTON has died at his home at Sheffield at the age of 93. For fifty years he was secretary and a director of Henry Bessemer & Company, Limited, now merged in John Baker & Bessemer, Limited, Rotherham.

WE REGRET to record the death of Mr. W. Noake, for many years associated with the management of the Patent Enamel Company, Limited, of Selly Oak, Birmingham. Mr. Noake was one of the founders of the Institute of Vitreous Enamellers, and was a member of the Council of that body from its inception to the time of his decease.

Company Reports

F. H. Lloyd & Company, Limited.—Interim dividend of 3 per cent.

British Piston Ring Company, Limited.—Interim dividend on the ordinary shares of 7½ per cent.

J. & E. Hall, Limited.—Dividend of 7 per cent. on the ordinary shares for the year ended September 30.

John Baker & Bessemer, Limited.—Dividend on the 6 per cent. cumulative preference shares for the half-year ended December 31, 1937.

Fairfield Shipbuilding & Engineering Company, Limited.—Dividend on the 6 per cent. cumulative preference shares for the half-year ended December 31 last.

Leyland Motors, Limited.—Balance available at September 30, 1937, after providing for taxation and contingencies out of the profits for the year and transferring £150,000 to the general reserve, of £281,163; dividend on the ordinary shares of 25 per cent.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Scottish Precision Castings, Limited.—Capital, £30,000. Directors: E. H. A. Carlton, A. F. Howard and C. R. D. Brown.

W. J. Eyre & Company (Engineers), Limited, 46, Hylton Street, Birmingham.—Capital, £1,000. Stampers, piercers, toolmakers, engineers, etc. Directors: W. J. Eyre and W. Scott.

British Manufacture & Research Company, Limited.—Capital, £100,000. Mechanical, electrical, constructional, marine engineers, etc. Subscribers: C. A. Fisher, Hillcroft, Moffats Lane, Brookmans Park, Herts; and J. L. Reed.

Contracts Open

Swansea, February 8.—Iron and steel, for the Town Council. The Borough Engineer, Guildhall, Swansea.

Long Eaton, February 5.—Cast-iron pipes, for the Urban District Council. Mr. H. Raven, engineer, Town Hall, Long Eaton.

Eastleigh, February 7.—Iron castings, for the Town Council. Mr. F. G. Lee, borough engineer, Town Hall, Eastleigh, Hampshire.

Loughborough, February 5.—Filtration and water purification plant, for the Leicestershire Education Committee. The Architect, County Education Office, Grey Friars, Leicester. (Fee, £1 1s., returnable.)

Forthcoming Events

FEBRUARY 2.

Manchester Metallurgical Society:—"Electrodeposition in the Engineering Industry." Paper by J. W. Cuthbertson, at the Constitutional Club, St. Ann's Street, Manchester, at 7 p.m.

Institute of British Foundrymen

FEBRUARY 2.

London Branch:—"Casting of Commercial Ingots." Paper by W. A. C. Newman, at Charing Cross Hotel, London, at 8 p.m.

FEBRUARY 3.

Sheffield Branch:—"Machine-Cast Pig-Iron." Paper by J. C. Jones, at Royal Victoria Hotel, Sheffield, at 7.30 p.m.

FEBRUARY 4.

Birmingham, Coventry and West Midlands Branch:—"Toughness of Cast Irons from Transverse Stress/Strain Curves." Paper by G. L. Harbach, at James Watt Memorial Institute, Great Charles Street, Birmingham, at 7.30 p.m.

FEBRUARY 5.

Falkirk Section:—"British Foundry School." Paper by J. Bamford, at Temperance Café, Lint Riggs, Falkirk, at 6 p.m.

Lancashire Branch:—Annual dinner, at Grand Hotel, Manchester.

Wales and Monmouth Branch:—"Patterns and their Relation to Moulding Problems." Paper by S. A. Horton, at University College, Cardiff, at 6.30 p.m.

The Institute of Vitreous Enamellers

FEBRUARY 3.

Southern Section:—"Application of the Radiant Tubular-Element System of Heating." Paper by A. A. Straub, at Charing Cross Hotel, London, at 8 p.m.

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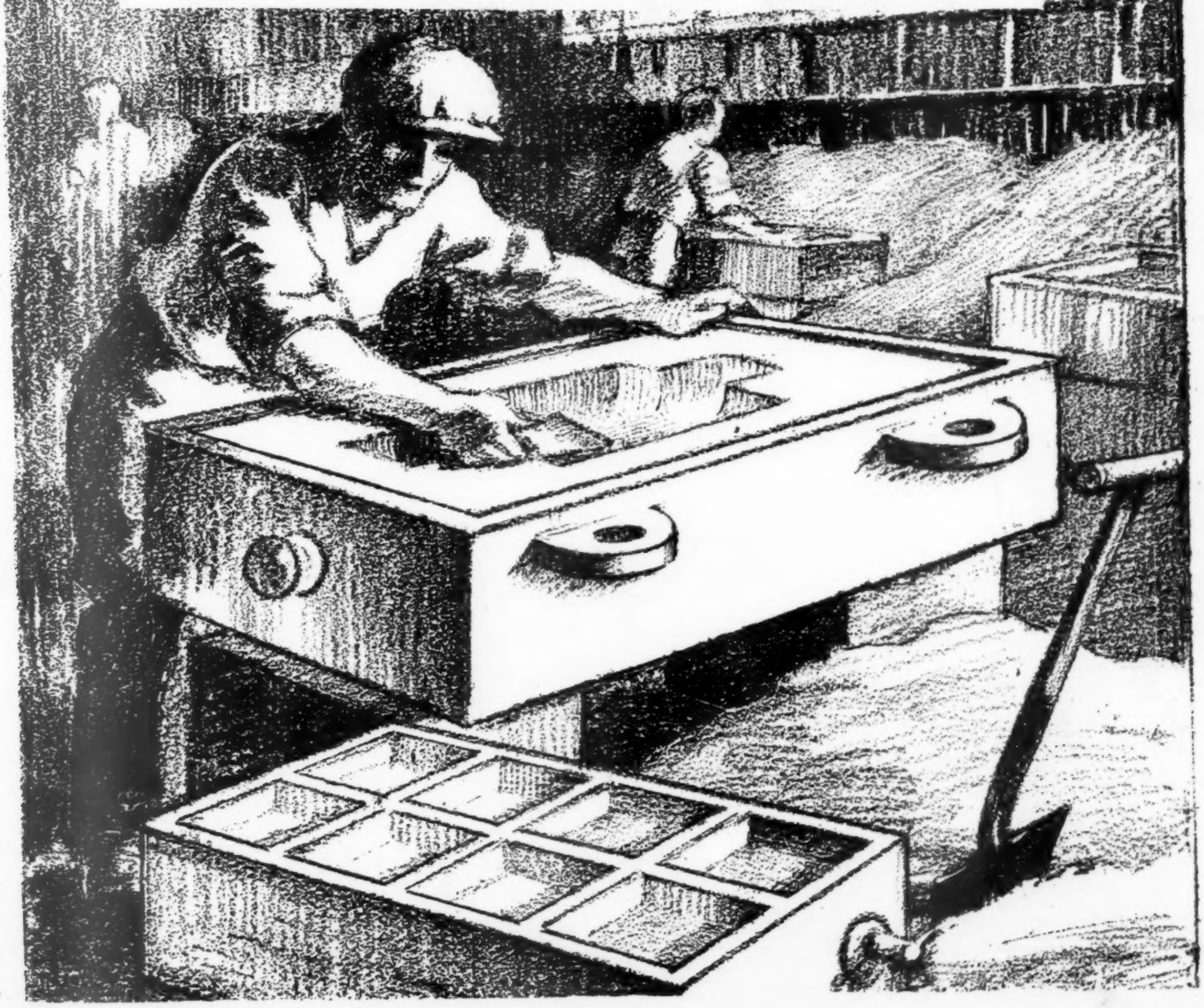
SCOTTISH OFFICE: 48, West Regent Street, Glasgow, C.2. Telephone: Douglas 6108 (3 lines). Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson).

SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs, Exchange Place. Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Russon).



Raw Material Markets

Deliveries of pig-iron have become easier to secure since the beginning of the year; improvement in this respect has been especially noticeable in the Cleveland area. Producers have still little to spare after contracts have been met, but business is being negotiated freely for forward deliveries, although order-books in many cases are now well filled.

Pig-Iron

MIDDLESBROUGH.—Now that supplies of locally-produced iron are available in better tonnages, consumers are taking less from other districts, the Midlands in particular. It is still difficult to find a producer on the North-East Coast willing to despatch supplies promptly, but generally they have accepted orders for deliveries over the first half of the year. Deliveries under contracts are satisfactory. For delivery in Middlesbrough and Falkirk, No. 3 Cleveland G.M.B. is quoted at 109s. per ton, No. 1 foundry at 111s. 6d., and No. 4 foundry and No. 4 forge at 108s. An extra 3s. per ton is charged for Clydeside deliveries.

The hematite market continues to be firm. In most cases, producers have had no difficulty in disposing of their full outputs for the first six months of the year. For delivery on the North-East Coast, East Coast mixed numbers are quoted at 132s. 6d., 138s. in Sheffield and 143s. 6d. per ton in the Midlands, less 5s. rebate.

LANCASHIRE.—There is a good call for contract deliveries in this area. Most consumers are well booked and new business is now on the quiet side. For delivery to users in the Lancashire price zone, offers of Derbyshire and Staffordshire brands of No. 3 foundry iron are on the basis of 114s., with Northamptonshire at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of consumer. West Coast mixed numbers of hematite are quoted at 141s., with East Coast at 140s. 6d. The demand for Scottish foundry iron at 141s. per ton is still in excess of the available supply.

MIDLANDS.—The demand for pig-iron is comparatively quiet at the present time and makers are able to build up stocks which will stand them in good stead when the call for supplies becomes heavier, as it is expected to in the near future when light-castings makers and the motor trade resume more active working. A fair amount of new business has already gone through, but producers have still a considerable proportion of their output to dispose of before the end of June. The demand for low-phosphorus iron is on a good scale at £6 7s. 6d. to £7 10s. per ton, while refined iron is quoted at £8 5s. New business in hematite is not too active at the present time; in most cases consumers can procure all they require under existing contracts, and there is now no sign of the scarcity which prevailed a few months ago. For delivery to Birmingham and Black Country stations, East Coast No. 3 is quoted at £7 3s. 6d., with West Coast mixed numbers at £7 4s. 6d., less 5s. rebate. An additional 1s. 6d. per ton is charged when delivered into works.

SCOTLAND.—Although no new orders for pig-iron are being placed on the Continent or in the United States, deliveries from these sources continue to arrive under contracts arranged before the introduction of the rebate scheme. On the whole, consumers in this area have ample iron to enable them to work normally, and there is certainly no rush to enter into new business. No. 3 foundry is quoted at 118s., with No. 1 at 120s. 6d. Prices of steel-making irons are as follow:—Hematite mixed numbers, 133s.; Scottish basic, 107s. 6d.; Indian and English basic, 100s., all less 5s. rebate, delivered local steelworks.

Coke

Although producers will sell at existing prices over the whole of the year, very little business has been done for the twelve months, as consumers anticipate reduced quotations in the summer. Requirements for the winter have been well covered.

Steel

Nearly all departments of the steel industry continue to operate at capacity and there is unrelaxed pressure on the part of consumers to secure delivery. The volume of new business, however, remains somewhat restricted, chiefly because the large consumers of steel have covered their requirements for the first half of the year, and neither they nor the producers are anxious to enter into commitments beyond that period. The demand for semi-finished material remains on a high scale, but is being met with greater regularity than at any time during last year. The British production of this class of steel has been increased and good quantities are arriving from the Continent. There is no relaxation in the pressure exercised by consumers of finished steel to obtain delivery against existing contracts, and the makers' arrears are gradually being reduced. The recent slight improvement in the demand from overseas markets has not been maintained and overseas buyers appear to be following a cautious policy, although in several markets stocks are understood to be low.

Scrap

The fact that imports of iron and steel scrap are now much less than they were a few months ago would appear to indicate that supplies of home-produced material are more plentiful. Nevertheless, there is still a scarcity of some grades, although the position is undoubtedly easier. Consumers continue to press for deliveries under contracts and there is no change in this respect.

Metals

Another quiet week has been experienced on the non-ferrous metal markets, and only small tonnages have changed hands.

Copper.—This market has been quiet, and business has involved only small tonnages. Inquiries from Japanese consumers have been fewer recently. Prices in the United States continue to fluctuate. The American Smelting & Refining Company has still further reduced its price to 10¼ cents per lb. The chief primary producers have reduced their quotation from 11 cents to 10.50 cents per lb. Business has continued to be on a moderate scale.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £41 12s. 6d. to £41 13s. 9d.; Friday, £41 1s. 3d. to £41 2s. 6d.; Monday, £40 1s. 3d. to £40 2s. 6d.; Tuesday, £39 15s. to £39 17s. 6d.; Wednesday, £40 3s. 9d. to £40 5s.

Three Months.—Thursday, £41 16s. 3d. to £41 17s. 6d.; Friday, £41 5s. to £41 6s. 3d.; Monday, £40 6s. 3d. to £40 7s. 6d.; Tuesday, £40 to £40 2s. 6d.; Wednesday, £40 7s. 6d. to £40 10s.

Tin.—There is little change to report in the condition of this market, which remains on the quiet side. Business is steady, but reveals no outstanding feature. The future of this market depends to a large extent on conditions in the United States; at the present time there is little prospect of any material improvement.

Further references to the buffer pool proposals have been made during the past week. Mr. C. L. Green, a member of the Council of the F.M.S. Chamber of Mines, at the annual meeting of Petaling Tin at Ipoh, on Monday, said that the scheme was thought by many to be both unnecessary and undesirable as an adjunct to the control scheme. He was most strongly of the opinion that Malaya would be very unwise to consider participating, unless the scheme was based on an equitable revision of the standard tonnages and contained satisfactory provisions for safeguarding Malaya's interests.

Interviewed upon his arrival at Malaya recently, Captain Oliver Lyttelton, chairman of the London Tin Corporation, and a director of Amalgamated Metal Corporation, expressed the opinion that Malaya's present criticism of a pool was unfortunate, because the actual proposals were not generally known there. Therefore, it was premature to condemn them. Captain Lyttelton further expressed the view that the operation of a pool should not be in brands, but in standard tin and confined solely to the London Metal Exchange. It would thereby be an uncompetitive organisation. He added that nothing would be done without Malaya's consent, and suggested the possibility of a referendum of the industry.

Official quotations were as follow:—

Cash.—Thursday, £182 5s. to £182 10s.; Friday, £182 5s. to £182 15s.; Monday, £180 15s. to £181 5s.; Tuesday, £180 10s. to £180 15s.; Wednesday, £181 to £181 10s.

Three Months.—Thursday, £183 5s. to £183 10s.; Friday, £183 5s. to £183 10s.; Monday, £181 15s. to £182; Tuesday, £181 5s. to £181 10s.; Wednesday, £182 to £182 5s.

Spelter.—New business has been on very small lines during the past week, the demand for all grades of metal being quiet. The galvanising trade both in this country and in the United States is still unsatisfactorily employed.

Daily market prices:—

Ordinary.—Thursday, £14 12s. 6d.; Friday, £14 8s. 9d.; Monday, £14 8s. 9d.; Tuesday, £14 10s.; Wednesday, £14 13s. 9d.

Lead.—According to the Metallgesellschaft, the world's smelter output of lead in November totalled 142,129 metric tons, making a total of 1,508,610 tons for the period January/November, 1937, against 1,318,766 tons in the corresponding period of the previous year. Only small tonnages have changed hands, and there is little alteration in the position of the lead market. Although the total value of building plans approved in December made the best showing for several months, confidence in the immediate future of this industry is still lacking. The increase in building plans over December, 1936, was 12.5 per cent. The total for December (for 140 authorities) was £9,764,400, compared with £8,677,200 for the same authorities in December, 1936. The increase in December was due to a rise in the housing total, from £5,174,500 to £6,910,300. All the other sections declined. The increase in housing was the result almost entirely of a substantial increase in the Scottish total.

Day-to-day quotations:—

Sotf Foreign (Prompt).—Thursday, £15 16s. 3d.; Friday, £15 8s. 9d.; Monday, £15 11s. 3d.; Tuesday, £15 11s. 3d.; Wednesday, £15 13s. 9d.

Scrap.—Business has been fairly active, but the demand has shown rather less expansion than had been anticipated. Prices in many cases have receded slightly.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £66; cast, £40; foil, £88 to £92. Copper, £39 to £43; braziery, £36. Brass (clean), £25 to £28. Zinc, £10. Lead, £15. Gunmetal, £41 to £43.

High-Density Alloy

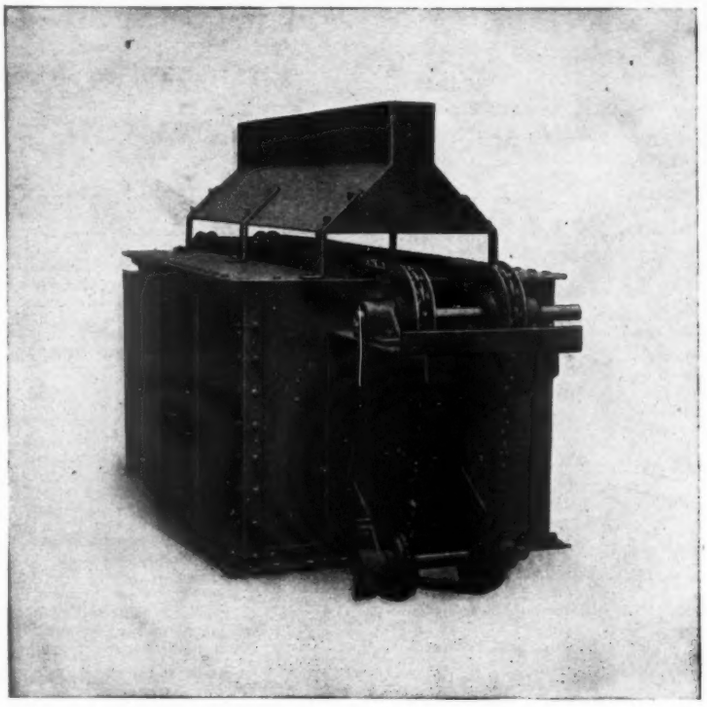
At a meeting of the London Branch of the Institute of Physics, held in London on January 18, a discussion took place on "New Materials in Industry." The discussion was sectionalised as follows:—(1) Alloys, (2) New Optical Materials and (3) New Dielectric Materials.

MR. E. A. G. LIDDIARD, of the British Non-Ferrous Metals Research Association, dealing with powder metallurgy, referred to a new high-density alloy. If tungsten powder was mixed with a small quantity of nickel and copper powder and subjected to considerable pressure and heated above the melting point of copper and nickel, a sintered alloy was obtained with a density of 16.5 grms. per cub. cm., which was considerably higher than the density of the heaviest commercial metal lead—11.34 grms. per cub. cm.

The importance of this new material was its application to radium beam therapy. It had a correspondingly higher absorption coefficient for X-rays and was, therefore, more effective than lead for protection purposes.

British Industries Fair

The heavy section of the British Industries Fair will open at Castle Bromwich on February 21 and continue until March 4. Other sections of the Fair will run simultaneously at Olympia and Earls Court, London.



CONTINUOUS CHAIN FURNACE

FOR LOCAL HEATING, HEATING FOR JOGGLING FISHPLATES, etc., etc.

Illustration shows oil-fired furnace, but any type can be arranged to suit requirements.

FURNACES, STOVES, SAND PLANTS

SPECIALISTS

COGGON FOUNDRY EQUIPMENT LTD Ovenden HALIFAX

Phone: 2423 Halifax Grams: COGGON, HALIFAX

"TICYL"

The NEW All-mine Blast Furnace . . .

CYLINDER PIG IRON

ANALYSIS %	
TOTAL CARBON	3·00
SILICON	1·75
SULPHUR	·06
PHOSPHORUS	·15
MANGANESE	1·00

or to suit customers' requirements

G. & R. THOMAS LTD HATHERTON

BLAST FURNACES • BLOXWICH • STAFFORDSHIRE

RAW MATERIALS—PRICE LIST

(Wednesday, January 26, 1938)

COPPER

	£	s.	d.
Standard cash	40	3	9
Three months	40	7	6
Electrolytic	44	0	0
Tough	43	3	9
Best selected	43	13	9
Sheets	75	8	9
India	56	6	3
Wire bars	44	18	9
Ingot bars	44	18	9
H.C. Wire rods	48	8	9
Off. av. cash, Dec.	39	19	8¼
Do., 3 mths., Dec.	40	4	3 9/11
Do., Sttlmnt., Dec.	39	19	6 8/11
Do., Electro, Dec.	44	10	4 1/11
Do., B.S., Dec.	44	8	7½
Do., Wire bars, Dec.	45	2	11 5/11
Solid drawn tubes			12¾d.
Brazed tubes			12¾d.
Wire			8¼d.

BRASS

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	9½d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8¾d.
Wire	8¾d.
Rolled metal	8½d.
Yellow metal rods	6½d.

TIN

	£	s.	d.
Standard cash	181	0	0
Three months	182	0	0
English	181	0	0
Bars	182	10	0
Straits	183	0	0
Eastern	184	5	0
Banca (nom.)		—	
Off. av. cash, Dec.	190	12	1 5/12
Do., 3 mths., Dec.	189	18	8 7/12
Do., Sttlmt., Dec.	190	11	9 9/11

SPELTER

	£	s.	d.
Ordinary	14	13	9
Remelted	11	15	0
Hard	11	10	0
Electro, 99.9	18	11	3
English	15	12	6
India	13	15	0
Zinc dust	22	0	0
Zinc ashes	5	10	0
Off. aver., Dec.	15	7	0 3/4
Aver., spot, Dec.	15	5	5 3/44

LEAD

	£	s.	d.
Soft foreign, ppt.	15	13	9
Empire (nom.)	16	7	6
English	17	15	0
Off. aver., Dec.	15	15	5 35/44
Aver., spot, Dec.	15	18	11 19/22

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	28	0	0 to 28	10	0	
Do., V.M. ex-whse.	28	0	0 to 28	10	0	
Rods			22	0	0	

ANTIMONY

	£	s.	d.	£	s.	d.
English	81	0	0 to 82	0	0	
Chinese, ex-whse.			68	0	0	
Crude, c.i.f.			41	0	0	

QUICKSILVER

	£	s.	d.
Quicksilver	12	17	3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£12 10 0
45/50%	£12 0 0
75%	£17 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	6/- lb. (nom.)
Tungsten metal powder—	
98/99%	6/1½ lb. (nom.)
Ferro-chrome—	
2/4% car.	£34 15 0
4/6% car.	£24 5 0
6/8% car.	£24 0 0
8/10% car.	£24 0 0
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 5 0
Max. 0.5% car.	£41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 10d.
Finished bars, 18% tungsten	5s. 0d.

Per lb. d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	8	9 to 3	11	3	
Mixed iron and steel	3	6	9 to 3	9	3	
Heavy cast iron	3	8	9 to 3	11	3	
Good machinery	3	15	0 to 3	17	6	
Cleveland—						
Heavy steel, best	3	7	0 to 3	9	6	
Steel turnings	2	13	0 to 2	15	6	
Heavy cast iron			4	5	0	
Heavy machinery			4	10	0	
Midlands—						
Short heavy steel			4	0	0	
Light cast-iron scrap			3	2	6	
Heavy wrought iron	4	0	0 to 4	5	0	
Steel turnings	2	6	3 to 2	8	9	
Scotland—						
Heavy steel, best	3	5	0 to 3	7	6	
Ordinary cast iron	4	5	0 to 4	7	6	
Cast-iron borings	2	0	6 to 2	3	0	
Wrot-iron piling	4	5	0 to 4	7	6	
Heavy machinery	4	10	0 to 4	12	6	

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	32	0	0
Brass	22	10	0
Lead (less usual draft)	13	10	0
Tea lead	10	0	0
Zinc	8	0	0
New aluminium cuttings	71	0	0
Braziery copper	30	10	0
Gunmetal	33	0	0
Hollow pewter	135	0	0
Shaded black pewter	97	0	0

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
,, No. 3	109/-
,, No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
,, d/d Birm.	144/6
Malleable iron d/d Birm.	165/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
,, No. 3 fdry.	111/-
Northants forge	107/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	110/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
,, fdry. No. 3	108/6
Lincs forge	107/6
,, fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Summerlee, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	13	5	0 to 13	15	0	
Nut and bolt iron	11	12	6 to 12	2	6	
Hoops			14	2	6	
Marked bars (Staffs) f.o.t.			15	15	0	
Gas strip			14	2	6	
Bolts and nuts, ¾ in. × 4 in.			17	10	0 and up	
Steel—						
Plates, ship, etc.	11	8	0 to 11	10	6	
Boiler plts.	11	18	0 to 12	0	6	
Chequer plts.			13	0	6	
Angles			11	0	6	
Tees			12	0	6	
Joists			11	0	6	
Rounds and squares, 3 in. to 5½ in.			12	0	6	
Rounds under 3 in. to ⅜ in. (untested)			11	9	0	
Flats—8 in. wide and over			11	5	6	
,, under 8 in. and over 5 in.			11	10	6	
Rails, heavy			10	2	6	
Fishplates			14	2	6	
Hoops (Staffs)			12	4	0	
Black sheets, 24g. (4-t. lots)			15	15	0	
Galv. cor. shts. (,,)			18	10	0	
Galv. flat shts. (,,)			19	0	0	
Galv. fencing wire, 8g. plain			20	5	0	
Billets, soft, 100-ton lots			7	17	6	
Sheet bars			7	15	0	
Tin bars			7	15	0	

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	11½d.
Wire	12⅞d.
Rods	13½d.
Tubes	18⅞d.
Castings	15½d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	39/6
,, furnace	32/6 to 37/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. British Channel ports.

I.C. cokes	20×14	per box	22/6 to 23/-
,,	28×20	,,	45/- to 46/-
,,	20×10	,,	34/9 to 35/3
,,	18¾×14	,,	24/9 to 25/3
C.W.	20×14	,,	18/3 to 19/-
,,	28×20	,,	36/6 to 38/-
,,	20×10	,,	30/- to 30/6
,,	18¾×14	,,	21/3 to 21/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£12	0	0 to £13	0	0	
Bars-hammered, basis	£20	0	0 to £22	0	0	
Bars and nail-rods, rolled, basis	£19	0	0 to £20	0	0	
Blooms	£18	0	0 to £19	0	0	
Keg steel	£30	0	0 to £35	0	0	
Faggot steel	£20	0	0 to £25	0	0	
Bars and rods dead soft st'l	£19	0	0 to £20	0	0	

All per English ton, f.o.b. Gothenburg [Subject to an exchange basis of Kr 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.		
Jan.	20 ..	41 12 6	dec.	13/9
,,	21 ..	41 1 3	,,	11/3
,,	24 ..	40 1 3	,,	20/-
,,	25 ..	39 15 0	,,	6/3
,,	26 ..	40 3 9	inc.	8/9

Electrolytic Copper

		£ s. d.		
Jan.	20 ..	45 10 0	dec.	20/-
,,	21 ..	44 15 0	,,	15/-
,,	24 ..	43 15 0	,,	20/-
,,	25 ..	43 10 0	,,	5/-
,,	26 ..	44 0 0	inc.	10/-

Standard Tin (cash)

		£ s. d.		
Jan.	20 ..	182 5 0	dec.	40/-
,,	21 ..	182 5 0	No change	
,,	24 ..	180 15 0	dec.	30/-
,,	25 ..	180 10 0	,,	5/-
,,	26 ..	181 0 0	inc.	10/-

Tin (English ingots)

		£ s. d.		
Jan.	20 ..	182 5 0	dec.	40/-
,,	21 ..	182 5 0	No change	
,,	24 ..	180 15 0	dec.	30/-
,,	25 ..	180 10 0	,,	5/-
,,	26 ..	181 0 0	inc.	10/-

Spelter (ordinary)

		£ s. d.		
Jan.	20 ..	14 12 6	dec.	8/9
,,	21 ..	14 8 9	,,	3/9
,,	24 ..	14 8 9	No change	
,,	25 ..	14 10 0	inc.	1/3
,,	26 ..	14 13 9	,,	3/9

Spelter (Electro, 99.9 per cent.)

		£ s. d.		
Jan.	20 ..	18 10 0	dec.	8/0
,,	21 ..	18 6 3	,,	3/9
,,	24 ..	18 7 6	inc.	1/3
,,	25 ..	18 7 6	No change	
,,	26 ..	18 11 3	inc.	3/9

Lead (soft foreign, prompt)

		£ s. d.		
Jan.	20 ..	15 16 3	dec.	5/-
,,	21 ..	15 8 9	,,	7/6
,,	24 ..	15 11 3	inc.	2/6
,,	25 ..	15 11 3	No change	
,,	26 ..	15 13 9	inc.	2/6

Lead (English)

		£ s. d.		
Jan.	20 ..	18 0 0	dec.	5/-
,,	21 ..	17 10 0	,,	10/-
,,	24 ..	17 10 0	No change	
,,	25 ..	17 15 0	inc.	5/-
,,	26 ..	17 15 0	No change	

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.*

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1897	41 2	40 4	40 5	39 2	39 7	40 9	39 6	40 5	41 7	42 5	41 5	40 4	40 7
1898	40 9	40 8	40 6	40 0	40 7	39 11	40 4	41 11	43 0	44 11	49 1	44 3	42 0
1899	46 10	47 11	47 9	49 10	55 11	62 10	71 6	65 9	67 7	68 8	70 0	66 9	60 5
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	43 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 6	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	42 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 6
1907	60 4	56 6	54 10	56 0	61 1	58 1	57 8	55 7	54 8	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 6½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	47 4½	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 5½
1913	66 11½	63 8½	64 8	67 1½	66 3	56 9½	56 3½	55 2	55 4	53 0	50 1	50 4	58 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	58 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7
1916	80 2	91 6	87 4½	86 10	82 6	82 6	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	99 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 8
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 3	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 3½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	128 1½	121 11	97 1½	97 0	100 0	100 0	110 6½
1924	99 10	97 3½	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2½	81 9	81 9	88 7½
1925	80 4½	78 10½	78 0	78 3	76 0	73 10½	71 7½	69 10½	68 1½	66 7½	66 0	66 10½	72 10½
1926	69 4½	70 0	70 0	70 0	72 6	75 10½	86 7½	90 0	93 10½	117 10	120 0	99 0	86 3
1927	85 0	83 1½	81 0	80 0	73 9	70 0	70 0	68 9	67 6	67 6	66 10½	65 0	73 2½
1928	65 0	65 0	65 6	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	65 9½
1929	66 0	66 9	67 0	68 1½	69 5	71 10½	72 9	72 6	72 6	72 6	72 6	72 6	70 4½
1930	72 6	72 6	70 0	67 6	67 6	67 6	67 6	64 6	63 6	63 6	63 6	63 6	66 11½
1931	59 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 7
1932	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6	58 6
1933	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6	62 6
1934	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	66 10½
1935	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	67 6	69 4½	70 0	67 10½
1936	70 0	70 0	70 0	70 0	70 0	70 0	75 0	75 0	75 0	75 0	81 0	73 0	
1937	81 0	81 0	81 0	81 0	81 0	81 0	101 0	101 0	101 0	101 0	106 0	106 0	91 10

*Delivered Middlesbrough area for years 1933 and onwards. Prior to 1933, prices were f.o.t. furnaces. NOTE: Prices have been subject to a rebate of 5/- per ton since November 1, 1937.

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EMPLOYMENT REGISTER.

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Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

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